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DIRECTOR OF SHIP MATERIAL
TECHNICAL REPORT

⑥ OPERATION CROSSROADS,
RADIOLOGICAL DECONTAMINATION
OF
TARGET AND NON-TARGET VESSELS,
VOLUME I.

*App. 1
C. 10. 1*

*9 Director of Ship Material Technical
inspection report*

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Page 1

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TABLE OF CONTENTS

Page

VOLUME 1

FLYLEAF	i
TABLE OF CONTENTS	2
Part I - Decontamination of Target Vessels	3-17
Part II - Decontamination of Non-Target Vessels	18-63
Part III - Future Decontamination Research Program	64-67
Appendix I - Reports of Target Vessel Decontamination	67-123
Appendix II - CJTF-1 Serial 079 of 9 September 1946	124-145

VOLUME 2

FLYLEAF	1
TABLE OF CONTENTS	2
Appendix III - Non-Target Vessel Experimental Decontamination Work	3-145

VOLUME 3

FLYLEAF	1
TABLE OF CONTENTS	2
Appendix IV - Decontamination and Ship Clearance Directives -	3-58
Appendix V - Miscellaneous Conference Notes	59-115
Appendix VI - Directives for Future Decontamination Research	116-123

NOTE: The above is a list of effective pages in these Volumes.
This is Volume 1 of 3.

Page 2

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Radiological Decontamination of Target and Non-Target Vessels

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PART I
DECONTAMINATION OF TARGET VESSELS

1. As a result of Test Able on 1 July, no extensive deposit of long life radioactive fission products or alpha emitters was found on the target vessels. Radioactivity existing was induced type and was of very short half life. Within a period of twenty four hours after fission of the bomb the level of radioactivity permitted reoccupation of surviving targets, with the exception of concrete barge YO-160, without radiological hazard. Consequently no decontamination of target vessels was required.
2. Consideration of radiological conditions which might be expected subsequent to Test Baker led to the conclusion that the most important effect from a radiological standpoint probably would be contamination of the lagoon waters. The conditions experienced in Test Able and had a close parallel in the previous three fissions, but the underwater burst was an entirely new phenomenon without precedent. A complete organization of personnel and instruments was set up to study and record the radiological conditions produced in the lagoon as a result of both Able and Baker fissions. This organization initially did not include, however, the gathering of complete scientific data concerning radioactivity on the target vessels.
3. It was recognized prior to Test Baker that (a) there was a possibility of considerable fall-out of radioactive matter from the cloud of water vapor which would be generated by the burst; (b) a wave approaching one hundred feet in height at the center of the array would dash large amounts of water against the target vessels. As a result of these two effects it was concluded that radioactive matter would be retained in undrained pockets about the weather decks of the target ships and that some would enter the interiors of the ships through vent ducts, stacks and other openings. In order to minimize this effect, all target vessels were secured as for heavy weather and temporary closures provided as practicable for openings caused by Test Able damage. Also, canvas covers were provided for stack openings, vent terminals and other openings not equipped with adequate closures. As a matter of safety and information, initial boarding teams also were instructed to note particularly the radiation conditions existing in pockets where contaminated water might collect. It is of interest to

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note at this point that the initial boarding teams were constituted primarily as a safety organization, with immediate damage and technical observation as a secondary function. Radiological conditions prevailing on the target ships were, at that time, of immediate interest to the Director of Ship Material only insofar as they related to safety of personnel reboarding the ship and in what respects they might impede reboarding, instrument recovery, rehabilitation and complete damage inspection of the targets.

4. The lagoon was reentered by the Director of Ship Material (in RECLAIMER) with vessels of the Salvage Unit (TU 1.2.7) in which boarding teams were embarked. It was found, as expected, that the lagoon waters were much more highly radioactive than after Test Able. Four vessels (APA's) in the southern string and one vessel in the southwest string could be approached and reboarded, as the water in their vicinity and the ships themselves were clear of radioactivity. Access to the remainder of the target array, however, was denied because of the high levels of radioactivity in the water. Some of the outer vessels were approached for short periods. It was found that every vessel approached showed from a distance, levels of radioactivity which would permit boarding for only short periods - generally less than an hour. On Baker plus one and Baker plus two it was possible to approach Hughes and Fallon, but both vessels were radioactive to the extent that taking them in tow for beaching required fast work. The fore-castle of HUGHES, for instance, had a tolerance time of about eight minutes. As the radioactivity in the lagoon decreased, it was possible, on Baker plus two and three, for the Director of Ship Material in RECLAIMER to survey quickly all target vessels from about 50 to 100 feet distant. Every ship, except those noted previously, had high radioactivity levels with the exception of CONYNGHAM and CARTERET at the end of the west and southwest strings, both of which had low levels.

5. Since the nature and extent of contamination of the targets was completely unexpected, no plans had been prepared for organized decontamination measures. It was immediately recognized that the functions of the Technical Director and the Director of Ship Material in the Crossroads Tests could not be completed without inordinate delay unless a means of decontaminating the ships expeditiously could be devised. The Director of Ship Material assumed the initiative in con-

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ducting preliminary tests, after conferences with the Radiological Safety Section, to determine whether the contaminating material was subject to removal by any simple and rapid means utilizing materail and equipment readily available.

6. Observations subsequent to Test Able had revealed that pools of water found on target ships were somewhat more radioactive than surrounding deck areas. It was therefore concluded that water might take up some of the radioactive materials in solution. Consequently, on 27 July some of the fire fighting vessels of the Salvare Unit (TU 1. 2.7) were employed to wash down with salt water HUGHES, which had been beached in radiologically clear water. After a wash down of about two hours' duration, radiation readings taken revealed that the intensity had been reduced about fifty percent. A second washing under similar conditions produced no further substantial reduction. Since the radiation readings now were 9.6 R/day on the forecstle and 36.0 R/day on the stern, it was obvious that some supplementary general contamination removal was required even to permit reboarding for limited periods.

7. The next step in the experimental removal of radioactivity was to try application of Foamite to the surfaces since abundant supplies were available in the area. Foamite has a soapy appearance and consistency, and it was hoped that it might have a detergent action with respect to removal of radioactive materials. Foamite was applied by Salvare Unit Vessels to HUGHES on 27 July and incompletely washed off with plain salt water. In areas where washing had been thorough, a resurvey indicated that the radiation intensity had again been reduced by fifty percent. Another application of Foamite was then made to HUGHES and allowed to remain overnight. The following day (28 July), a thorough wash down with salt water, again using the Salvare Unit Vessels' fire fighting facilities, once more reduced the level of activity by fifty percent. The maximum readings at this time were 3.0 R/day port, and 8.5 R/day starboard, with an average of about 2.0 R/day on the main and forecstle deck levels. The high reading on the starboard side was considered attributable to the fact that the beached location of the ship allowed use of monitor nozzles only on the port side in washing, whereas portable pumps in an LCM were used for the starboard side wash. The reduction in readings obtained was

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most encouraging and, although much of it was due to natural decay, there was no doubt that considerable acceleration had been produced by the processes being used. This fact was further borne out by the differences between the radiation intensities on the port and starboard sides as mentioned. As a result of these experiments, it was felt that, pending development of better methods, washing and foamite applications should be made in accordance with a prepared schedule as soon as practicable and as consistent with considerations of salvage operations, recovery of instruments and the value of target vessels as technical specimens. It had been found from experience in the period since Test Baker that water slightly contaminated tended to deposit its contained radioactive materials on surfaces of systems and equipment exposed to sea water and in marine growths on underwater bodies of operating vessels. It was therefore necessary to wait until the salt water surrounding the target vessels was radiologically clear before proceeding with the washing. It was also obvious that the washing methods developed were not by any means a complete nor a wholly satisfactory solution to the problem and that further study was imperative.

8. On 27 July a conference was held with the Radiological Safety Section in which the need for developing a satisfactory method of rapid removal of radioactive materials from the targets was emphasized. It was requested that a detailed study be undertaken immediately to evolve a suitable method. In response to this request various samples of contaminated equipment were selected for conduct of special tests by the Radiological Safety Group. The objects were blasted with soft grits such as ground corn cobs, coconut shells, rice, barley, ground coffee, rice hulls and sand using a diesel driven air compressor rated at 315 cu. ft. per minute at 90 psi., and introducing the material through a simple eductor arrangement. The specimens treated included electric lanterns, copper pipe, a plastic coffee maker, angle irons, aluminum angles and sheets, a brass boat hook, junction boxes of brass and bakelite, a brass shower drain screen and galvanized steel plate. The following were the findings of the tests:

(a) Painting over the surface produced no reduction in activity since the radiation was primarily gamma.

SECRET

(b) Blasting copper pipe with grain rice reduced activity to one-half, but complete removal could be achieved only with sand.

(c) Painted objects could be partially decontaminated by blasting with coffee without injury to the surface, but complete decontamination required removal of all paint.

(d) Radiation intensity from a brass casting which was porous from dezincification was reduced from 4.5/R to 2.0 R/24 hrs. by blasting with rice, but further treatment with rice or sand failed to yield additional results.

(e) Brass surfaces could be decontaminated with nitric acid. These findings showed that radioactive material could be removed from surfaces by wet sandblasting, or partially by blasting with various soft grits. However, these measures are not suitable for general decontamination of a target ship in the field and their usefulness was restricted primarily to clearing local areas.

9. The Director of Ship Material made a small scale laboratory study on 28 and 29 July to investigate the possibility of decontaminating by use of various materials available locally or readily obtainable from Pearl Harbor. The possible methods of removal of radioactive materials investigated were (a) detergent action by soap powders, lye and volatile naphtha; (b) dissolving action by acetic, hydrochloric and sulphuric acids; (c) absorption by flour, cornstarch, activated charcoal and sandblasting. The first results of the investigation revealed that the source of the radioactivity lay in the collection of radioactive materials on or in wood, paint coverings on metal, and on rough and rusted metal surfaces. It also was noted that radioactive materials were retained to a remarkable degree by all exposed organic materials such as canvas, life rafts, manila line, swabs, brooms, wood decks and the like, and all exposed items of these materials observed were very heavily contaminated. All of the reagents listed above were tried on painted wood, steel and canvas surfaces. None was successful in the removal of the radioactive materials with the exception of a prolonged washing in a five percent solution of acetic acid solution. This process was not suitable for expeditious mass application to the target ships by methods known at the time. The other reagents accomplished reduction of radioactivity only to the extent that they actually removed the paint or surface corrosion.

10. On 28 - 30 July a series of experiments on a larger scale was conducted supplementing the laboratory studies. A vessel of the Salvage Unit sprayed exposed surfaces of TUNA first with diesel oil and later with a solution of lye and boiler compound. Each application was followed by a thorough washing with plain salt water. The diesel oil produced negligible results, but the lye and boiler compound solution reduced the average readings immediately by about sixty-six percent. The same solution on SKATE produced very poor results, but a large portion of the superstructure of this ship was missing as a result of Test Able and most of the remaining surfaces were painted with black plastic or bituminous enamels which were not affected by the lye solution. The application of lye and boiler compound on TUNA had removed a considerable proportion of the paint from exposed surfaces. Both the laboratory and large scale experiments of 28 - 30 July thus clearly indicated that the most practicable means of early decontamination of the target vessels lay in the use of a mixture having detergent qualities strong enough to remove outer layers of paint. The problem remaining was to develop techniques and procure the necessary materials and equipment to accomplish this end.

11. The method selected for the actual removal of contaminated materials was based on the reduction of radiation intensities by use of wholesale washing processes until levels were reached at which inspection and instrumentation personnel and small groups of ship's force could remain aboard safely for periods of at least two hours. Ship's personnel in relays would then apply detailed scrubbing, abrasive and paint removal action as necessary to reduce the radioactivity sufficiently to permit continuous habitation of the ships. It was also an urgent necessity to remove animals to obtain instrumentation records and to proceed with post-technical inspections. Some vessels required reboarding for pumping out flooded spaces. Appropriate instructions as to procedures to be followed, clothing to be worn and detailed safety precautions were promulgated to all target ships. In addition, necessary personnel were informed as to the methods to be used and the hazards involved, by conducted demonstrations to school ships' crews in the operations to be followed. Detailed instructions issued by the Director of Ship Material are included with Appendix IV.

SECRET

12. Briefly, the program consisted of the following steps:

(a) Ship thoroughly washed down with plain salt water.

(b) Radiological monitor, DSM representative and ship's force representative board ship, make quick preliminary survey of radiological conditions and note particularly hazardous areas. Boarding party together with Commanding Officer of salvage vessel formulate plan of action to proceed with decontamination.

(c) If conditions permit, ship's force working party boards vessel, removes all exposed organic materials, working in relays as necessary to avoid overexposure. If radiation intensities still prohibit this action, paint removal mixture must first be applied as below.

(d) Prepare paint removal mixture of 450 lbs. lye, 600 lbs. boiler compound and 75 lbs. of cornstarch with sufficient water to produce 1000 gallons of mixture. Lye and boiler compound are added gradually to 500 gallons of water, mixed and dissolved. Cornstarch is mixed separately in a thin suspension and added gradually to produce smooth suspension. Fresh water is added to produce 1000 gallons. Batch is heated by steam hose until starch swells and boiler compound dissolves completely. The mixture is applied by Chrysler salvage pump taking suction on tank and discharging through 1 1/2" fire hose with all purpose nozzle or fog nozzle with applicator. All painted surfaces of the target vessel are thoroughly coated with the mixture. After an interval of about two hours ship is again hosed down vigorously using monitor nozzles with maximum force available to remove all possible paint. Care is exercised to leave no gaps and to sweep all paint chips clear frequently by use of the hose in order to minimize transfer of contamination to other surfaces.

(e) Following this process, target vessels are again re-boarded by the DSM representative with a monitor, Radsafe representative and a responsible officer from the target vessel. The general radiation level is checked at this boarding to ascertain whether the vessel is not safe for small working parties is relays to apply detailed decontamination measures. All spots remaining highly

SECRET

radioactive are noted and the source of the excessive radiation determined if practicable. If the spots are too extensive and apparently the result of gaps in the paint removal process, it may be necessary to repeat the applicable steps in the paint removal procedure to reduce the activity of the recalcitrant areas. If, on the other hand the vessel is determined to be safe for working periods of four or more hours, detailed decontamination measures by the ship's force can proceed.

(f) For prosecution of detailed decontamination procedures, all radiological dangers when found are marked clearly and if necessary roped off to keep personnel at a safe distance. Monitors are present at all times to insure that personnel do not remain on the ship beyond tolerance hours set. Detergent mixtures similar to those used for the gross decontamination are applied to painted surfaces remaining above tolerance for continuous habitation. Long handled scrubbers, holystones, and other similar devices are used to scrub the surfaces, and any available means of aiding the mixture in the removal of paint, rust, scale and the like are resorted to. Each operation is followed by a vigorous, plain salt water hosing to wash all removed contaminated material from the ship. The process is repeated several times in affected areas until tolerance limits for continuous operation are attained.

13. General washing with salt water and application of this formula carried out during the period of the above investigations in accordance with a priority list as soon as the water around each of the involved vessels became clear; the use of foamite was abandoned as being less effective. Detailed decontamination by ship's force in accordance with the instructions promulgated by the Director of Ship Material was commenced at once on the lightly contaminated vessels such as CONYNGHAM, WAINWRIGHT, CARTERET and SALT LAKE CITY. Meanwhile ten vessels of the Salvage Unit (TU 1.2.7) were outfitted to carry out the gross decontamination of other more heavily contaminated targets by applying the detergent mixture. This outfitting was completed on 5 August. Five APA's, BLADEN, CORTLAND, FILLMORE, GENEVA and NIAGARA, not exposed to the radioactive fall-out, had been cleared on Baker Day. These vessels were reboarded immediately and accomplished local decontamination by scrubbing with soap and water and washing down sufficiently to obtain radiological clearance for complete rehabilitation.

SECRET

14. The application of the new gross decontamination measures progressed very satisfactorily in spite of many handicaps. Decontamination by ship's force was begun on the following target vessels in addition to the five APA's which had already been cleared as stated above:

SALT LAKE CITY	(CA 25)
NEW YORK	(BB 34)
NEVADA	(BB 36)
PENNSYLVANIA	(BB 38)
PRINZ EUGEN	(IX 300)
CARTERET	(APA 70)
WAINWRIGHT	(DD 419)
CONYNGHAM	(DD 371)
MUGFORD	(DD 389)
WILSON	(DD 408)
PARCHE	(SS 384)
DENTUDA	(SS 335)
TUNA	(SS 203)
SKATE	(SS 305)
SEARAVEN	(SS 196)

Appendix I contains detailed reports of procedures followed on several representative ships.

15. The accomplishment of the gross decontamination measures involved many practical difficulties and many hazards. Great care was necessary to insure that the length of time during which the salvage vessel might be alongside the target without dangerous exposure was not exceeded. It was, of course, highly desirable for the salvage vessel actually to put a line over to the target vessel to insure an effective treatment of the target, but some targets were radioactive to a degree which prohibited closing to less than fifty feet except for very limited periods. Great care was necessary also to avoid washing contaminated materials into the target vessels. In addition it was necessary to skip entirely certain areas around open hatches, large air intakes and other openings to prevent introduction of large volumes of water and paint removal mixture into the ship's interiors. Aside from all this, the paint removal material itself, containing large quantities of lye, was

SECRET

Page 11

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hazardous to handle. Protection of personnel against both chemical and radioactive hazards was of paramount importance during these operations.

16. The work required by ship's force decontamination was laborious and largely manual; it required considerable time and hazards were involved from the standpoint of both radiological considerations and danger of injury in handling paint removal mixtures prescribed. In the course of the work, decontamination of specified areas of steel decks was attempted by use of scrubbers with strong solutions of first acetic, then hydrochloric acids following each scrubbing with a thorough wash with salt water. The superiority of this process over scrubbing with plain salt water was not sufficiently marked to justify adoption. In view of later information and experience, however, it is considered that because the areas so treated were small and surrounded by large masses of radioactive material, the readings obtained were indicative of the general radiation level or "background" of the vicinity rather than the condition of the treated surface. However, general acid application was not developed into a practical method. Attempts were made to reduce the activity of wood decks by holystoning with sand, lye and boiler compound on SALT LAKE CITY and NEW YORK. NEW YORK's decks showed considerable acceleration over natural decay rates, but SALT LAKE CITY's indicated no improvement. The lack of success in the latter case is considered at least partially attributable to the fact that adjacent painted steel surfaces were being decontaminated simultaneously and, as a result, contaminated water was being washed over the wood decks almost constantly. Also the ship's general radiation level undoubtedly obscured the actual results.

17. During the course of decontamination by ship's force, elaborate measures were required to protect personnel against radiological hazards. In addition to providing monitors on all ships at all times that personnel were aboard, rubber boots and rubber gloves were necessary since shoes and cloth or leather gloves are quickly contaminated, and the fission products attaching themselves are most difficult to remove even by laundering. All personnel were required to be fully clothed at all times and to take showers and change clothes after each operation. All clothing worn was required to be laundered after

SECRET

each day's work. Special change facilities and showers were set aside for this purpose on the target APA's which had been cleared. Special laundry facilities were also designated for washing the contaminated clothing in order to avoid contaminating general laundries. Even with the most elaborate precautions it was necessary to exercise constant vigilance to insure that all personnel were safeguarded adequately. In spite of all handicaps, however, the work proceeded very satisfactorily.

18. On 9 August, the Director of Ship Material requested the Radiological Safety Officer and the Commander Target Group to visit ships on which ship's force were employing the detailed decontamination procedures. During that inspection, samples of materials were obtained from areas of the wardroom of PRINZ EUGEN for which geiger counter readings showed radiation intensities sufficiently low to permit extended personnel exposure without danger of injury. An analysis of the samples revealed the presence of alpha emitters which were not detectable with the monitoring instruments in use at Bikini. Further investigation showed probable widespread presence of the alpha emitter in the target area even in spaces not obviously contaminated. Since no alpha detectors for general field use were available and the alpha emitters are one of the most poisonous chemicals known, their presence was considered a serious and indeterminate menace to personnel exposed for indefinite periods of time on contaminated target vessels without special complex protective equipment and trained personnel to detect the alpha emitters. A conference was called by the Task Force Commander on 10 August to discuss the matter. As a result of this conference, continuation of detailed decontamination was considered unsafe under the existing conditions, and all further decontamination work on the targets by ship's force was ordered discontinued. Subsequently, all further work on these vessels by Task Force Personnel was limited to recovery of instruments, limited surveys, salvage work and preparations for towing from the area.

19. It was unfortunate in many respects that the decontamination procedures instituted had to be discontinued as a result of the investigation requested by the Director of Ship Material on 9 August. It is fortunate, of course, that the analysis of remaining products was made since the facts revealed thereby precluded the possibility of exposing large numbers of personnel to a hazard not detectable by instruments at hand. However, the planned procedures of pre-

SECRET

liminary decontamination by spraying and washing from salvage vessels close aboard, followed by short clean-up and monitoring of upper decks, with thorough spraying and washing from alongside as necessary, and finally, detailed decontamination by the ship's crew were not carried out for a sufficient period to permit proper evaluation or determination of ability to reduce levels of radioactivity to acceptable tolerances by these methods. Even if this had been possible, the removal of alpha emitters would still have been a problem not susceptible to field solution.

20. In order to appraise the value and effectiveness of the decontamination procedures that were used on the surfaces of the target vessels, it is necessary to examine briefly the nature of the contamination existing. Post-Baker investigation revealed that about fifty percent of the total radioactive material produced by the explosion remained in the waters of the lagoon. Readings taken at very early stages showed that invariably the largest part of this material was deposited on the surface of the water and very little, if any, was present near the bottom. This means that most of the contamination resulted from the base surge, the following wave and then the rain and spray fall out which covered the bulk of the target area for a considerable time after detonation. In the cloud resulting from the explosion there were in addition to the fission products, undoubtedly elements from the sea water which had induced radioactivity, the most important being sodium. The materials were rained down on the ships over a wide area and upon evaporation of the water were deposited on the surfaces where they fell. Large quantities of highly radioactive coral and sand also were deposited on the ships. The area affected extended from about 1800 yards upwind to more than 4000 yards downwind and about 3000 yards crosswind. All but nine of the target vessels in the array were heavily contaminated by the rain and spray. Most of the water deposited ran off the ships and such variations as existed in degree of contamination were probably due to the characteristics of the design of the ship, its age and the condition of the exposed surfaces rather than its distance from the center of fission. It is also possible that the rain was at an elevated temperature and tended to penetrate and soften the paint as well as deposit itself on the surface. The concept of contamination by the "base surge", or wave of vapor emanating from the center of fission, is as yet imperfectly understood. More study of this phenomenon may modify considerably some of the above assumptions. The retention on the surfaces also was aided by ion-ex-

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change since the long lived fission products deposited in seawater are known to be largely polyvalent cations which would displace easily the monovalent sodium and potassium cations which would normally be present on paint, rust, scale, algae and similar surfaces exposed constantly to sea water and known to have a high ion-exchange capacity. Further, the fact that fission products were present in low concentration and submicroscopic form, even though the solutions were highly radioactive, aided the exchange absorption of the products.

21. Accurate evaluation of the decontamination measures instituted is very difficult to make because of unreliability of instruments, the irregular variation of readings and the lack of uniformity in methods of reporting radioactivity. Also, data are incomplete since many of the ships were too highly radioactive to board prior to first gross decontamination. Probably as a result of ion-exchange as discussed above, all rust, dirt, loose paint and organic materials tended to hold the contamination and became much more highly radioactive than clean, well drained surfaces. The initial washing process removed much of the material of this type, but probably did very little, if anything, toward removing imbedded or attached ionized radioactive materials from surfaces remaining. The lye-boiler compound - starch mixture developed for the purpose was designed to have a detergent action and to remove the outer paint layer and the attached or imbedded radioactive materials with it. It is significant to note that the processes used were effective only insofar as they accomplished this function. It was found in the short experience gained that difficulties of application on the large scale required also prevented better results. Furthermore, there was the necessity for haste in order to complete the Director of Ship Material and Technical Director missions, and to avoid retaining any of the Task Force in the lagoon under undetermined conditions of exposure more than a minimum of time. Some of the contamination was transferred to under surfaces, corners, scuppers and drains and resisted removal by the methods in use. The procedures adopted did not have a pronounced effect on wood decks, canvas or unpainted surfaces. The abrasive scrubbing with sand and holystones was successful to some degree on wood and bare surfaces insofar as it removed the outer and more heavily contaminated surfaces. There is some doubt as to the efficacy of the holystoning on the decks, however, as it appears that some of the activity re-

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moved was re-transferred to the cleaned surfaces in the associated washing and that one effect may have been to drive the radioactive material in deeper.

22. The gross decontamination by Salvage Unit vessels from alongside was fairly successful in cleaning the ship as a whole and also in concentrating on limited areas. The higher structures of the targets were difficult to reach to apply the paint & removal mixture. Further, this mixture did not loosen the paint to a sufficient degree to permit removal by ordinary washing but required the full force of a stream from a monitor fire-fighting nozzle to realize good results. Because of this fact, removal of paint from most of the upper decks of target vessels was incomplete since the monitor nozzles could not be brought to bear forcibly by reason of height and screening of the areas by splinter and weather shields. That the work was generally effective, however, can be illustrated by a specific case such as the BRACKEN. This vessel received a complete gross decontamination, but no ship's force work was accomplished. On boarding to remove animals on 27 and 28 July, the average geiger counter reading on the exposed main and superstructure decks was 11.0 R/29 hours. The ship was given a coat of foamite on 31 July and washed the following day. The ship was again washed down on 3 August and on completion of this treatment showed an average topside reading of 1.7 R. On 6 and 7 August the ship was sprayed with paint removal mixture and after washing down showed an average reading of 0.3 R/24 hours, and an elapse of two more weeks would have been required for the average intensity of radiation to have reached 0.3 R/24 hours by natural decay.

23. It is regrettable that necessary procedures were not established for obtaining more accurate and detailed information as to conditions of radioactivity existing on target vessels both before and after decontamination. Pressure of time and limitations of facilities, instruments and personnel available, however, precluded the achievement of this goal. Much also can be ascribed naturally to the lack of information and realization of the conditions to be expected. Consequently, it was impossible to plan for them, which is to be expected in the first experience with a phenomenon of this magnitude and scope. The decontamination measures adopted as an ex-

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pedient after Test Baker, although successful to a certain extent in the limited application they received, revealed conclusively that removal of radioactive contamination of the type encountered in the target vessels in Test Baker cannot be accomplished satisfactorily for wartime application from the standpoint of time and effort with standard equipment now readily available. The measures employed, however, were effective enough to permit removal of instruments and instrumentation records, technical inspection of the vessels, removal of animals and salvage operations. Otherwise portions of the Task Force would have been delayed in the lagoon for one to two months.

24. The following program of further action in radiological decontamination investigation and development was clearly indicated as a result of the early experience with Crossroads targets:

(a) Extensive study and analysis to determine the exact nature of the contamination resulting from Test Baker.

(b) Broad research to develop satisfactory methods of large scale decontamination of ships.

(c) Careful study of surface characteristics with respect to radioactive contamination and research to develop suitable surfaces to minimize contamination.

(d) Appropriate education of naval personnel in matters of radiological hazard and instruction in methods of decontamination when developed satisfactorily.

(e) Necessary design changes in ships to reduce contamination and its effects and to facilitate removal of such contamination as cannot be avoided.

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PART II

DECONTAMINATION OF NON-TARGET VESSELS

1. As stated in Section I above, it was noted soon after Test Baker that the radioactive fission products were absorbed readily by rusty, porous and scaly surfaces loose paint, marine growths and algae. This fact was demonstrated forcibly on the lightly contaminated target APA's, which showed considerable radiation intensities on the outer shell in the vicinity of the waterline. The radioactive materials were lodged almost entirely in the marine growth and rust adhering to the shell. These vessels using ordinary paddle type bottom scrapers removed as much as practicable of the growth in the waterline area and thereby reduced considerably the amount of activity in that vicinity. They next proceeded outside the lagoon and steamed at high speed for a period of about 24 hours. The erosion of the water incident to this steaming resulted in a further reduction by about fifty percent. Continued steaming did not result in additional reduction of activity, however. Upon return to port, GENEVA wire-dragged the entire bottom using hogging lines and walking them down the length of the ship. This operation resulted in reducing the radiation levels inside the ship in the vicinity of the shell to tolerance limits for continuous occupancy.

2. After re-entry of the non-target vessels to the lagoon, the same tendency of radioactive materials to adhere to the outer shell below the waterline was observed. The conditions here were ideal for ion-exchange and although the water itself showed intensity of radioactivity at and near the surface of only about .01 R/day, the active matter was absorbed so efficiently from the lagoon waters that within a period of three days several of the non-target vessels began to show geiger counter readings of greater than 0.1 R/day of gamma radiation inside the hull in the vicinity of the waterline. Consequently, these areas became unsatisfactory for continuous occupancy. In addition, salt water lines and salt water systems continuously circulating lagoon water in firemain, condensers and evaporators began to show increasing gamma radiation readings on exterior surfaces to the extent that certain areas adjacent to these systems were in excess of tolerance. A potential hazard to personnel

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standing watches near this equipment was apparent if vessels were permitted to remain in lagoon areas contaminated to any appreciable degree.

3. Upon discovery of the radiological conditions prevailing and the constant increase in contamination being suffered, all non-target vessels and those target vessels which had been cleared were moved to the southeastern portion of the lagoon, where the waters were clear, to await the action of natural decay and dispersion of activity by tides and currents in the normal anchorage area. Meanwhile, it was realized that wherever algae, rust, sediment and calcareous marine growths on the ships' hulls or in the ships were exposed to radioactive materials in the water there would be an ever increasing absorption of the materials taking place. Furthermore, the action of evaporators tended to deposit this material in the scale on the shells and tubes, indicating that radioactive elements were either in solution or suspension in the waters of the lagoon. The removal of scale by manual methods therefore became a hazardous matter, because of the high gamma and beta radiation intensities encountered as a result of this accumulation.

4. All vessels were directed to list ship as much as practicable by shifting liquids and to scrape algae, fouling and scale from portions of underwater bodies thus exposed. This operation aided considerably in reducing the activity in the waterline area of the ships. In addition, strict instructions were issued to all vessels not to open up evaporators without specific authority from the Radiological Safety Section and then only in the presence of a qualified monitor.

5. It was obvious that the only feasible immediate means of reducing and maintaining at low levels concentrations of radioactive materials in evaporators lay in removing scale by non-manual methods and attempting to reduce or eliminate reformation of this scale. Tests were conducted and showed that so long as evaporators were operated at low enough rates to prevent priming, no carry-over of radioactive products into distilled water would result. As a factor of safety, however, all ships were directed to steam evaporators not in excess of 80% of capacity. In order to remove scale existing, all ships equipped to do so were ordered to cold shock tube nests. To reduce to a minimum formation of additional scale, standard instruct-

SECRET

ions, for introduction of boiler compound and cornstarch into evaporator feed water on a continuous basis, which had been universally successful in reducing hard scale formation in naval vessels, were republished by the Director of Ship Material and the Force Maintenance Section and distributed to all non-target vessels. The application of these measures resulted in the reduction of activity in most ships to tolerance levels (0.1 R/day or less gamma) and further significant increases in activity were avoided by keeping the bulk of the non-target ships in waters which showed less than .001 R/day of gamma radiation. In order to carry on essential functions a good many exceptions were necessary, however such as the vessels of the Salvage Unit which were working with the Director of Ship Material on decontamination and inspection of the targets, the vessels of the Radiological Safety Patrol which were monitoring the target ships and the lagoon waters, the Survey Unit craft which were engaged in obtaining scientific data incident to the tests and several others. The only immediate solution on these vessels lay in constant monitoring, restriction of hazardous areas, and scheduling of operations wherever possible in a manner designed to avoid further increase in radioactivity of portions of the ship already at dangerous levels. No satisfactory means of decontamination of underwater bodies and salt water systems in the Bikini area was apparent. In some extreme cases vessels were actually anchored and personnel evacuated for radiological safety reasons until the radioactivity had decayed sufficiently to permit continuous habitation and performance of essential functions without exposing personnel to more than 0.1 R/day.

6. During the period subsequent to Test Baker, all non-target vessels of the Task Force which had re-entered the lagoon and had any possibility of being contaminated to any appreciable degree were monitored carefully. Each of these vessels which showed radiological contamination of sufficient intensity to produce any possibility of over-exposure of personnel to gamma radiation was provided with instructions as to steps to be taken to prevent radiation injury. These instructions in most cases consisted in the main of limitations on the time any person would be permitted to remain in a particular compartment or vicinity of a piece of equipment which was heavily contaminated. It was hoped that the extensive steaming in the open sea following departure from the Bikini area combined with natural decay would remove all radioactivity hazards to personnel on non-

SECRET

target vessels. Because of lack of sufficient detailed information, it was not possible at that time to predict how long the existing contamination would continue at sufficient intensity to represent a hazard.

7. It became apparent as time went on that natural decay and normal steaming in uncontaminated water would not necessarily reduce the radioactivity to negligible amounts. All ships which had been in Bikini lagoon during any part of the period from 25 July to 10 August were advised therefore by CJTF-1, Serial 075 (included as an enclosure to Serial 079 in Appendix II) on 19 August that further monitoring would be required before ships could be considered completely clear of radioactivity, particularly to insure safety of personnel engaged in future work on ships' sides and evaporators since these had been found to be the two principal collecting points for radioactive matter on the non-target vessels. Arrangements were made immediately to provide radiological monitors to medical officers of the 11th, 12th, 13th and 14th Naval Districts and Guam to be available for call to activities handling suspect vessels. Commanding Officers of ships involved were advised to apply to District Medical Officers for such monitors prior to opening up evaporators or other contaminated machinery and before entering drydock.

8. The Radiological Safety Advisor and the Safety Advisor concluded, after further study and analysis, that the precautions outlined in the instructions of 19 August were inadequate for protection of personnel against possible injurious effects resulting from introduction of alpha emitters into their bodies by exposure to contaminated surfaces or dust and fumes emanating from these areas, irrespective of the gamma and beta radiation hazards. It also was decided at that time that considerable cleaning would in some cases be required to eliminate this additional potential hazard, and that the cleaning operations and the disposal of the products involved constituted new problems of a unique nature. On 29 August Commander Service Force Pacific, after conference with the Safety Advisors, promulgated special precautionary measures to be taken immediately until further development of the situation, and to be applied to all vessels exposed an accumulated time of ten or more days in Bikini lagoon subsequent to 25 July. The precautions were briefly as follows:

SECRET

- (a) Avoid drydocking until receipt of detailed instructions.
- (b) Avoid exposing any internal or external salt water surfaces.
- (c) Avoid exposing personnel to fumes resulting from welding or cutting, or dust originating from surfaces contaminated by salt water.

A copy of this directive is included as part of Appendix IV. Commander Service Force Pacific also recommended assembly of all vessels, other than targets, exposed ten or more days and at or en-route to the West Coast, in one area, preferably San Francisco, for detailed determination of radiological status and proper indoctrination of personnel concerned in future operation and disposition of the ships. San Francisco was suggested because of favorable anchorages and proximity of radiological laboratories. For the ships in the Pearl Harbor area, Commander Service Force stated that suitable radiological personnel would be provided and maintained in that location.

9. On 28 August, Commander Joint Task Force One in a message to the Chief of Naval Operations and the Commander in Chief Pacific concurred in the precautions and recommendations set forth by Commander Service Force. Commander Joint Task Force One cited, however, the undesirability of returning ships in the Marianas, Philippine or Asiatic waters to San Francisco, and advised that necessary monitors and equipment could be flown to Guam or other selected location for clearance of vessels concerned. He advised also that a monitoring organization was being arranged to be available to Commander Naval Base, San Francisco or other authority to whom returning ships would report on arrival, and would provide clearance facilities at Pearl Harbor. Commander Joint Task One recommended that immediate steps be taken meanwhile to avoid docking or yard work on any of these ships until after complete monitoring and clearance had been accomplished, and noted that the precautions set forth for suspect ships also applied to boats carried by those ships.

10. The Chief of Naval Operations directed compliance with the recommendations of Commander Joint Task Force One on the same day (28 August), and on 30 August directed that all boats found radiologically unsafe after monitoring under the direction of District Medical Officers be sunk at sea in deep water. Later, on

SECRET

3 September, the Chief of Naval Operations modified his original orders by informing the Commander in Chief Pacific and Commander Western Sea Frontier that diversion of some Crossroads ships to other principal West Coast Ports as mutually satisfactory to the commands addressed was authorized if unacceptable congestion in the San Francisco area would result otherwise. At the same time he advised that Commander Joint Task Force One would provide monitoring and clearance at other ports when advised of diversions, but directed that diversions be held to an essential minimum because of superior radiological safety facilities in the San Francisco area. In this dispatch he also suggested that vessels concerned in the Marshalls and destined for Eastward proceed to Pearl Harbor or San Francisco, preferably the latter. On 3 September, the Chief of Naval Operations also directed the Bureau of Ships to comply with Commander Joint Task Force One recommendations that drydocking and Navy yard work be avoided until complete radiological monitoring and clearance had been obtained.

11. In order to implement the ship clearance program, the Force Medical Officer, Captain W. E. Walsh, (MC) USN, had been detailed to brief District Medical Officers at Pearl Harbor and on the West Coast, and to establish the contemplated ship clearance organization. On 28 August, Captain Walsh set up headquarters in the offices of the District Medical Officer, Twelfth Naval District, and thereby officially established the ship clearance organization in its first form. The terminology and functions of this organization were later defined by Commander Joint Task Force One as follows:

(a) Clearance is the certification of the fact that a ship is radiologically safe for unrestricted use.

(b) The provision of clearance facilities includes not only the furnishing of monitors and certification of clearance if the ship is found uncontaminated, but also the rendering of advice and technical assistance to accomplish the elimination of such contamination as is found to exist.

(c) In some cases it will be found impracticable to accomplish this complete elimination, whereupon only a conditional clearance will be given setting forth what further decontamination will be required and what precautions must be taken in the interim.

SECRET

12. The ship clearance organization at the outset had considerable difficulty in obtaining sufficient radiological monitors to handle the vessels arriving in San Francisco. Additional personnel were obtained from HAVEN and from officers who had served as monitors during the period at Bikini. It became apparent immediately, however, that the problem in hand was far greater than had been anticipated and that extensive decontamination of most of the returning vessels would be required before complete clearance could be granted. This realization was further complicated by the fact that no safe and effective methods were yet known by which the radioactive materials could be removed from surfaces and systems of the type and on the extensive scale required by contaminated ships. The measures recommended by the monitors in accordance with the information provided them were, at best, only partially effective and grossly inadequate to meet the problem. They consisted largely of precautionary measures without positive steps to eliminate the hazard except by such removal as might occur through continued use of the parts affected. These measures were principally as follows:

(a) Treat evaporators by use of starch and boiler compound, cold shocking, or, in the case of vapor compression stills, standard acid cleaning.

(b) Sink at sea radiologically hazardous lines, fenders, nets, camels, brooms, swabs and other fibrous, vegetable materials.

(c) Prohibit burning, welding, chipping or wire brushing of salt water lines or exposed salt water surfaces except under supervision of monitor. Scraping is permitted on surfaces provided they are kept wet at all times.

(d) When dropping the anchor keep personnel away from the dust formed, deep anchor chain as wet as possible during the process and use gloves when handling, discarding gloves after use.

(e) Sink in deep water small boats or parts thereof with readings in excess of 0.1 R/day. For other boats showing appreciable readings, scrape all wood and metal surfaces using a completely wet technique; catch scrapings on a canvas spread below the boat and discard overboard; paint all boats; replace all boat salt water lines as soon as possible as a further safeguard.

(f) Scrub all urinals and head troughs with abrasive cleaner and/or acid solution.

SECRET

13. The limited decontamination measures outlined above combined with additional decay incident to the operation of the contaminated ships resulted in almost all cases in only conditional clearance. The Commander in Chief Pacific on 7 September expressed considerable concern over this situation pointing out that such clearance would permit temporary operation, but in most instances would result in eventual immobilization because of restrictions on work. The conviction was expressed that Commander Joint Task Force One should initiate early action to establish procedures and facilities for the complete radiological clearance of all contaminated vessels, particularly those assigned to active fleets. The unsatisfactory situation prevailing was echoed by Commander Western Sea Frontier in a dispatch of 9 September to the Commander in Chief Pacific. In this communication, Commander Western Sea Frontier stated that districts had insufficient personnel to effect full clearance of vessels and, furthermore, no one yet knew how to decontaminate. Consequently, several APA's, Destroyer Division 72 and some auxiliaries had been cleared partially to meet operational requirements on the basis that they might as well continue to operate until methods of making them safe for overhaul were developed. The thought was expressed that all vessels so cleared would be required to return to San Francisco for full clearance when more information had been developed. On this score, there was no estimate as to time which might be required. Commander Western Sea Frontier flatly stated that the insufficiency of the measures being employed was recognized clearly and that every effort was being made to expedite means of dealing more fully with the problem.

14. On 9 September 1946, Commander Joint Task Force One promulgated his serial 079 addressed to the Commanding Officers of all Crossroads non-target vessels which were suspected of being contaminated by radioactive material. The stated purpose of this letter was to advise all Commanding Officers of the nature and content of the important pertinent communications which circulated the information as to the radiological contamination of the non-target ships, to summarize safety precautions and to give information as to the monitoring and clearance organization and procedure. A copy of this serial is attached as Appendix II. Serial 079 did an admirable job of supplying information intended. However, it accomplished little, if anything, towards expediting final radiological clearance for the following reasons:

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(a) It failed to establish adequate decontamination procedures or to set up a plan for developing them.

(b) It did not establish the final tolerance for the alleged principal radioactive hazard, alpha emitters.

(c) It did not specifically place the responsibility on any command or group for accomplishment of decontamination and obtaining final clearance.

On the same date, Commander Joint Task Force One designated Captain W. E. Walsh by dispatch as his representative in coordinating radiological monitoring and clearance of ships in the 11th, 12th, 13th, 14th Naval Districts and at Guam.

15. All cognizant commands were becoming exercised over the disruption of operational, overhaul and demobilization schedules caused by the almost universal contamination of the returning non-targets and the apparent lack of success in dealing with the matter. This attitude was reflected by a dispatch from Commander in Chief Pacific to the Chief of Naval Operations on 10 September in which the former suggested that vessels whose condition warranted only conditional radiological clearance be sailed to berthing or disposal areas for decontamination in order to release personnel of radioactive ships destined for the Nineteenth Fleet and for disposal. The Chief of Naval Operations concurred in this movement as mutually agreeable to Commander in Chief Pacific and Commander Western Sea Frontier. On 11 September, however, Commander Western Sea Frontier advised the Chief of Naval Operations that although he appreciated the urgent need for release of crews, considered that it was impossible to determine whether the work could be done at berthing and disposal areas since no one yet knew how to decontaminate. In this same dispatch Commander Western Sea Frontier cited the fact that current directives failed to assign responsibility for decontamination and merely provided that representatives of Joint Task Force One would give advice as to precautions. Expressing concern lest the vagueness as to who was responsible for initiating yard work for radiological purification might have unfortunate consequences, he submitted the following specific recommendations:

(a) Assign highest priority to provision of technical staff for Captain Walsh.

SECRET

(b) Assign the Bureau of Ships the responsibility for developing practical methods for making ships radiologically safe and have Bureau of Ships deal with District Commandants and Shipyard Commanders in this matter through the normal chain of authority. Since problems are coastwise, Commander Western Sea Frontier should be responsible for coordinating district activities in this matter.

(c) Send Admiral Solberg or a similarly qualified line officer to the West Coast as representative of the Bureau of Ships to study the problem.

On the same day, the District Medical Officer of the Twelfth Naval District initiated a dispatch to Commander Joint Task Force One strongly recommending that Admiral Solberg with Bureau of Ships personnel assist in studying decontamination problems.

16. On 13 September the Chief of Naval Operations advised Commander Western Sea Frontier that the Bureau of Ships was charged with developing methods and equipment for decontamination of radiologically active ships and stated that this responsibility would require considerable time and liaison with Manhattan District to develop practical procedures. The Chief of Naval Operations also advised that Rear Admiral Solberg would arrive 17 September to discuss the problems, and authorized Commander Western Sea Frontier to assign restricted availability for shipyard work when required in connection with radiological clearance.

17. Meanwhile, some experimental work on decontamination was proceeding. Commander Western Sea Frontier had on 30 August directed the Commandant 12th Naval District to drydock one or more vessels of Destroyer Division 71, then present at San Francisco Naval Shipyard, in a floating drydock as "guinea pigs" for radiological monitoring as requested by the Radiological Safety Advisor, Joint Task Force One. Pursuant to this authority, LAFFEY (DD 724) was dry-docked in Floating Repair Dock ARD 32 at San Francisco Naval Shipyard for radiological inspection on 5 September. The inspection was conducted under the supervision of Captain Walsh. Other members of the inspection party were Dr. Robert A. Newell, Stanford University, radiologist; Dr. F. H. Rodenbaugh, San Francisco, radiologist; Lt. Wayne A. Chadburn (MC) USN, special monitor. The inspection was also witnessed by representatives of the 12th Naval District and Commander Western Sea Frontier. Shipyard personnel assisted under the direction of Lt. Comdr. M. E. Turnbaugh, USN., Asst. Repair Supt. (Hull). Prior to the start of pumping operations, water
SECRET

around LAFHEY was tested for radioactivity with negative results. When pumping had been completed the ship's bottom was monitored and found to be below tolerance levels for gamma radiation. Samples of bottom scrapings were collected for laboratory analysis and for shipment to the Navy Department in Washington. Subsequent to the hull inspection, samples of scale were obtained by chipping scale from first effect tube nest of the forward engine room evaporators, also a cannister mask was worn during the chipping to provide a sample of solid material in the atmosphere which could be analyzed for possible presence of radioactive particles. As the next step, a section of four inch salt water piping was removed from the sea suction of the evaporator distiller pump for analysis at the University of California Radiation Laboratory. Monitor readings during the tests showed salt water lines to be more heavily contaminated than the underwater body, but still not to the extent of producing a radiation hazard to personnel. No positive results were obtained immediately from this inspection as conclusions were dependent on laboratory analysis. Elaborate precautions were observed throughout this operation to protect personnel against any possible hazard. These precautions included complete suits of special clothing, lectures of explanation enjoining personnel to avoid diligently contact with or ingestion of suspect materials, monitoring of personnel and clothing after completion of inspections, and provision of oxygen masks during chipping. As a precautionary measure, also, instructions were issued to wet down the outer hull of LAFHEY four times daily while in dock until the inspection board had granted definite clearance.

18. On 6 September, Captain Walsh advised the San Francisco Naval Shipyard that it would be satisfactory on WALKER, BARTON, LAFHEY and LOWRY to proceed with all repair and alteration work with the exception of that on the underwater body or any machinery in which radioactively contaminated salt water had been circulated. The Shipyard proceeded on this basis with work on all Bikini ships present, but held in abeyance all work on parts of ships touched by salt water of Bikini lagoon until monitors could be provided to inspect and issue specific precautions for each job depending on the conclusions reached on tests in hand. A "Changing and Decontamination Center" for yard workmen was set up at the Submarine Barracks with elaborate and complete clothes changing, lavatory, shower and eating facilities.

SECRET

19. On 12 September Captain Walsh arranged for a small section of the underwater body of LAFFEY to be sandblasted using the standard wet sandblast process. During the blasting there was set up on the skipbox carrying the sandblaster a Filter Queen to collect particles of dust in the immediate vicinity for analysis of radioactive matter contained and determination of the inhalation hazard. At the same time an electrostatic dust precipitator was set up on the floor of the dock near the test section for the same purpose. Subsequently, a section of radioactive, galvanized steel, salt water piping was unbolted from its location in the line and was burned through in a small closed compartment, with the Filter Queen again used to collect dust samples from the fumes to determine the respiratory hazard incident to burning pipe. These tests were attended by Dr. K. G. Scott from the Crocker Radiation Laboratory of University of California. Dr. Scott took all filters used to the Laboratory for analysis.

20. On 13 and 19 September, the filter tests of sandblasting operations were repeated but on a much larger scale using two 1000 c.f.m. blowers and collecting dust on filters made of heavily packed glass wool 2 inches thick. Also, on 14 September, at the request of Captain Walsh, a portion of LAFFEY's copper-nickel firemain was isolated for introduction of a solution developed by the Crocker Radiation Laboratory for experimentation on the original section of evaporator line provided from LAFFEY. The solution was made of 25 gallons of water, 48 lbs. of acetic acid powder and 34 lbs. of ammonium hydroxide sufficient to reduce the acidity of the solution to pH 6.0. The section of firemain selected for the test was filled with the solution prepared, about 30 gallons being required, and allowed to stand for 72 hours. At the end of this period, the contents of the pipe section were blown by air into a barrel on the main deck. The solution discharged into the barrel showed radioactivity averaging about .01 R/day indicating that a large part of the radioactive material from the pipe had been removed from the line by the solution. One quart of the solution was taken by Dr. Scott for laboratory analysis. After evacuation of the decontaminating solution, the pipe section was flushed with fresh water and the discharge collected in a second barrel. The water showed no appreciable radioactivity, hence the discharge line was put over the side and flushing resumed and continued throughout the night. The treatment was successful in removing about 90% of the radioactivity, but did not dislodge any appreciable amount of marine growth.

SECRET

Geiger readings on the outside of the pipe before treatment ranged from .008 to .02, and on the inside from .05 to .5. After treatment, readings outside were from "background" to .007, and inside from .008 to .06.

21. Additional experimentation at Crocker Laboratory had indicated the possibility of using a dilute solution of hydrochloric acid for removal of marine growth and scale, and hence the contained radioactive materials, from piping systems. Consequently, on 17 September, a section of approximately 50 feet of copper-nickel firemain piping on LAFHEY was blanked off, fitted with hose connections, flushed with fresh water for 30 minutes, then a 1.08 normal solution of hydrochloric acid circulated through the section. Within a matter of minutes, the reservoir used for recirculating the acids showed the presence of radioactivity. The normality of the acid was checked periodically and found to decrease, then level off at about 0.45 normal after eight hours. Shortly thereafter, circulation was discontinued and the section under test was blown clear by air. Somewhat later, flushing with fresh water was commenced. Only the first barrel of flushing water showed radioactivity. Flushing was continued for one hour and ten minutes. The outside of the pipe was monitored and a second acid circulation phase commenced using a new mixture of 0.89 normal strength. This phase was continued for four hours and was followed by fresh water flushing for forty-five minutes. The hydrochloric acid treatment proved to be eminently successful having removed 98% of the radioactivity and all marine growth and scale from the pipe. Geiger readings on the outside of the pipe were .01 to .08 before treatment, .007 to .029 after the first phase and .001 or less throughout after the second phase. The inside of the pipe showed readings from .08 to .5 prior to treatment and .001 to .002 upon completion. This experiment was considered completely successful. Since the normality of the acid in the second phase of the treatment was not affected appreciably, it was concluded that this phase was unnecessary.

22. On 17 September, Rear Admiral Solberg, the Director of Ship Material, arrived on the West Coast for the purpose of conferring on conditions existing in non-target vessels and assisting in clarifying and developing procedures necessary to establish normal operating and upkeep conditions on these vessels. Admiral Solberg reported to the Commandant Twelfth Naval District and later to Commander Western Sea Frontier providing these two commands with all information

SECRET

available from Washington, D. C., and outlining his proposed plans for accomplishing his objective. Admiral Solberg conferred with Captain Walsh, Radiological Safety Representative, and Dr. Scott of the University of California, at which time he was apprised of the type and laboratory results of the investigations conducted to date on the cross-roads non-target ships at Naval Shipyard, San Francisco. After the conference he visited the San Francisco Naval Shipyard to witness experimental work and to discuss further experimental work and inspections to be accomplished to aid in establishing methods of handling each of the problems of the contaminated ships. The following are the highlights of plans and developments set forth by Admiral Solberg at the first Shipyard conference:

(a) Subject matter on how to rid a ship of radioactivity was to be classified "Top Secret".

(b) The Bureau of Ships would set up a "Decontamination Section" which would be interested in and would desire all information concerning experimental work being conducted at San Francisco.

(c) Information to date indicated that sandblasting of LAFLEY would be safe, and final decision in the matter would be given to the yard the following day.

(d) The Shipyard was to prepare for decontamination of BENEVOLENCE evaporators by acid cleaning. Final orders would be given after inspection the following day.

(e) The Shipyard was to prepare the following items for Admiral Solberg's inspection at 1300 on the following day:

(1) The two sections of the firemain of LAFLEY which had been cleaned, and adjacent sections for comparison in judging effectiveness of decontamination processes in removing marine growth.

(2) Evaporator on BENEVOLENCE open for examination for radioactivity; scale samples available for inspection.

(3) One auxiliary condenser open and a zinc available for examination.

(4) The Shipyard was to remove several salt water valves from LAFLEY for tests involving soaking them in decontamination solutions to determine whether this means was sufficient to remove radioactivity to the extent necessary to permit valves to be sent to shop for work without further radiological safety precautions.

SECRET

23. Meanwhile, also on 17 September, preparations were made on HENRICO to determine the effectiveness of the ammonium citrate solution and the hydrochloric acid solution on steel piping. For this purpose, two sections of the flushing system, one for trial of each solution, which showed sufficient radioactivity to yield positive results were selected and all arrangements started to commence the tests on the following day.

24. At this juncture, information from the laboratory analysis of the first radioactive materials removed from the non-target ships became available. Since plutonium was not directly detectable by available field instruments it was desirable to determine the fluctuation of the ratio of plutonium to fission products in any particular contaminated area. For this purpose a series of quantitative measurements of contaminating materials was conducted on samples of rust, evaporator scale, salt water lines, algae from the hull water line and removable surfaces of the hull. These materials had been collected from KENNETH WHITING, HENRICO, MOUNT MCKINLEY and LAFFEY. The analysis showed the amount of plutonium associated with fission products to be nearly constant. With this information it became possible to estimate plutonium concentration without submitting to the labor and delay involved in conducting a plutonium analysis. Specifically, the quantity of plutonium exposed incident to any particular operation could be determined from the samples obtained on vessels in the Shipyard.

25. Samples and studies on LAFFEY had shown that removal of paint from the underwater body by normal wet sandblasting removed the activity. Further, the deposit of fission products on the filters used to determine the amount of radioactivity released to the air by the blasting operation showed no detectable plutonium. However, application of the previously determined fission products - plutonium ratio to calculate the amount present, revealed that one hundred million days of hull cleaning per individual would be necessary before dangerous quantities of plutonium could be inhaled if no respirator was used. This finding indicated that wet sandblasting of contaminated ships' hulls at least one hundred times as radioactive as LAFFEY would be safe as far as lung hazards were concerned. Similar preliminary tests were made on samples of products deposited on filter paper by fumes collected from welding on contaminated salt water

SECRET

lines. Insufficient plutonium was deposited to be detectable on the measuring instruments available. This test indicated therefore that at least one thousand days of welding would be necessary for one individual to accumulate dangerous quantities of plutonium in his body. From all preliminary tests, it thus appeared entirely feasible to decontaminate and repair Crossroads non-target vessels without exposing personnel to radiological hazards.

26. On 18 September Admiral Solberg again conferred with Commander Western Sea Frontier and Commander Naval Shipyard, San Francisco on the overall aspects of the radiological decontamination problem. The high points of this conference were as follows:

(a) LAFFEY was to be considered an example of a ship with least hull contamination, having been in Bikini lagoon for only ten days subsequent to Test Baker and having plastic paint on the bottom.

(b) A ship having commercial underwater body paint and having been in the lagoon over the longest period subsequent to Test Baker would be considered as representing the case of maximum underbody contamination. This ship would be selected from available records, dry docked and the hull examined carefully. The data obtained would be compared with that from LAFFEY and would form the basis for decision as to whether all contaminated ships should be drydocked immediately or cognizant agencies merely notified to observe certain special precautions at the next normal docking period.

(c) Graving docks could be used for drydocking contaminated vessels.

(d) An additional burning experiment on highly radioactive piping was being planned for collection of fumes. This would represent the extreme case of this type, and analysis of the deposit together with data already available would reveal definitely any danger involved in working radioactive materials.

(e) The worst possible situation would be that complete decontamination by methods under development or similar would be necessary before work could proceed on suspect ships.

(f) The optimum situation would be that no decontamination would be required before working radioactive surfaces.

(g) Captain Walsh was to continue to issue "clearance for sailing" on the lines of existing policy.

SECRET

27. Following the conference, Admiral Solberg's party with interested yard personnel inspected experimental work on LAFHEY and BENEVOLENCE. Since the BENEVOLENCE evaporator scale showed more than twice the tolerance limit (0.1 R/day), it was ordered on the spot that cleaning be effected by the hydrochloric acid method previously standard in the Navy. Also, the No. 1 auxiliary condenser zincs showed high concentration of radioactivity, hence the ship was directed to replace all zincs immediately.

28. After the inspection trip, a broad program of immediate experimental decontamination work to be undertaken by the Shipyard was laid out. Details of this program and other experimental decontamination work undertaken are included in Appendix III. The general nature and results of the experiments will be discussed in a later section.

29. On 19 September, Admiral Solberg issued a memorandum to the Commander Naval Shipyard, San Francisco, specifying general test procedures to be followed in decontaminating all Crossroads non-target ships in the yard. It was directed that accurate records of all operations be kept by the Shipyard and copies furnished to the Bureau of Ships and Captain Walsh. A copy of this memorandum, together with subsequent directives of a similar nature, are included in Appendix IV. In general, the procedures specified were as follows:

(a) Salt water systems.

(1) Circulate ammonium citrate solution of predetermined strength through entire systems for approximately one hour.

(2) Flush with neutralizing solution of boiler compound and fresh water.

(b) Salt water piping system samples.

(1) Prior to cleaning, obtain samples of copper-nickel and iron piping about three inches long from salt water systems and test in three different concentrations of hydrochloric acid solutions: 1/2, 3/4 and 1 normal. Object of these tests is to determine effect of various solutions on cleaning marine growth, rust and other foreign matter from inside of piping. Make quantitative measurements of marine growth, rust and other foreign matter on the interior of the pipe before and during the testing.

SECRET

(2) Forward similar samples to Dr. Scott at the University of California.

(c) Heat transfer units and evaporators.

(1) On first cleaning, crack off all possible scale deposits by using thermal shock treatment.

(2) Remove scale using standard safety precautions.

(3) Complete removal of scale by using a muriatic acid solution.

(4) Have a monitor present at all times when opening up a unit in accordance with the above procedure.

(5) Segregate and dump at sea all scale removed.

(d) Ship's side in dry dock.

(1) Scrape all marine growth from ship's side keeping wet while scraping down.

(2) Clean from drydock, segregate and dump at sea all material scraped from ship's sides.

(3) Remove remainder of paint from underwater hull by wet sandblasting using standard equipment. Dump sand at sea.

30. On 20 September, Admiral Solberg informed Commander Western Sea Frontier of the conclusions thus far reached on the decontamination investigations and the proposed decisions for implementation in Washington. He then advised Captain Walsh of all investigations in progress or planned, and departed for Washington leaving two EDO officers, Captain W. S. Maxwell and Commander J. B. Shirley, to carry on the investigation work, and indicated the possibility of sending another officer, Commander E. J. Hoffman, from Washington to assist. On arrival in Washington, Admiral Solberg immediately proceeded with preparation of a directive covering the phases of decontamination which had been settled. This directive was issued as joint Bureau of Ships-Bureau of Medicine and Surgery Confidential Speedletter, Serial 1381, on 24 September. It included authority and directions for all contaminated ships scheduled to remain in the active fleet for decontamination of evaporators, heat transfer apparatus except condensers, underwater bodies and ships' boats.

SECRET

This letter also lifted the restriction on dry docking and repair of contaminated ships, requiring only that certain simple safety precautions be observed in directly handling contaminated materials or surfaces. A copy of this letter is contained in Appendix IV.

31. Serial 1381 was received with great enthusiasm by all commands concerned since it was the first specific indication that a solution to the problem was in sight, and it contained detailed instructions as to measures to be taken to clear ships of contaminating material. It also had the salutary effect of relieving the apprehension created by Commander Joint Task Force One Serial 079 as to the great and indeterminate hazard to which all personnel dealing with the suspect ships were liable to be exposed. It contained positive statements to the effect that routine repairs and operations could be undertaken without danger as demonstrated by actual tests. It also indicated that further information could be expected at an early date, particularly with respect to ships scheduled for disposal and inactivation.

32. Upon receipt of the new directive, work was started immediately to decontaminate ships in accordance with the instructions contained. Meanwhile Captain Maxwell proceeded to the Thirteenth Naval District to confer with the District Commandant and the Commander Naval Shipyard, Puget Sound to apprise them of the latest findings and procedures with respect to decontamination, and to interpret for them the new instructions. Shortly thereafter, Captain Maxwell proceeded to the Eleventh Naval District and Commander Shirley to Pearl Harbor for the same purpose. Appropriate safety precautions and instructions for prosecution of work on contaminated ships were promulgated immediately at these locations with the advice and information furnished by the Bureau of Ships representatives.

33. At the same time, the program of experimental decontamination work at Naval Shipyard, San Francisco set up by Admiral Solberg, looking toward improvement of methods and a greater fund of information on the subject, was prosecuted on a high priority basis. The following is a brief summary of the investigations in progress from 18 September to 1 October with the results obtained in each case. Appendix III contains detailed reports:

SECRET

(a) Evaporators on HENRICO and BENEVOLENCE were cleaned by circulating a solution of one normal hydrochloric acid and fresh water through the entire salt water system, draining and collecting used acid solution, neutralizing with a solution of boiler compound and water, then flushing thoroughly. On the first cleaning, on BENEVOLENCE, the level of the acid solution was carried in the shell only to the top of the tube nest. Inspection after cleaning revealed that a large quantity of scale remained in the top of the shell producing an average reading of 0.24 R/day gb.* The equipment was therefore rearranged to effect a complete washing process, filling shells completely, and the procedure repeated. This treatment was highly successful and all external readings were reduced to .01 R/day or less.

* gb - combined gamma and beta radiation.

(b) Two highly contaminated sections of the ferrous piping of the flushing system on HENRICO were selected for comparison of the effectiveness of hydrochloric acid solution and the ammonium citrate solution. One normal hydrochloric acid was circulated for twelve hours in the first section, 5.95 pH ammonium citrate for seventy-two hours in the second. Each section was given a thorough flushing subsequent to treatment. The readings in R/day obtained were as follows:

	Hydrochloric Acid		Ammonium Citrate	
	Before	After	Before	After
Outside Reading (g)	.003 - .02	Background	.002 - .014	.000 - .002
Inside Reading (gb)	.007 - .4	.002 - .008	.012 - .5	.003 - .08

The ammonium citrate was not effective in removing scale. The hydrochloric acid removed practically all scale and marine growth.

(c) Entire salt water systems of HENRICO and BENEVOLENCE were flushed with fresh water at high velocity for twelve hours in an attempt to determine whether the scouring effect of the water flow would remove activity. No measurable effect was produced.

SECRET

(d) Two short sections of contaminated fire main piping, one copper-nickel from LAFHEY and one ferrous from BOTTINEAU, were fitted with flanges and lines to permit steam, water or air to pass through. Steam was sent through each section until the outside temperature reached approximately 180° F. Immediately, cold water at 60° F. was run through the lines at high velocity. Under these conditions the temperature leveled off in about thirty seconds. The effect of the cold shocking operation produced reduction in maximum readings as follows:

	Copper-nickel		Iron	
	Before	After	Before	After
Outside (g)	.014	.003	.07	.003
Inside (gb)	.20	.06	.5	.01

All marine growth was removed from the copper-nickel pipe. The iron pipe had not been fouled, but was scaly. The scale was not affected appreciably.

(e) A 16" steel crossover line providing lower suction for three auxiliary condensers on BENEVOLENCE showed external readings ranging from 0.1 to 0.9 R/day gamma which were too high to permit sailing to carry out the operational schedule. Two cold shock treatments, one to 170° F., and one to 195° F., were tried with no results. A 2 normal solution of hydrochloric acid was then circulated through the line for one hour and forty minutes, neutralized with soda ash solution and flushed thoroughly. The acid cleaning reduced readings to a range of .005 - .07 R/day. An interesting discovery made during this treatment was that tapping the pipe in the vicinity of highest readings was very effective in removing concentrations of radioactive material during the acid circulation.

(f) Several sections of contaminated copper-nickel and steel piping were treated with solutions of boiler compound and water as follows to determine the effect on radioactivity:

- (1) Boiler compound and fresh water circulating for four hours.
- (2) Boiler compound and fresh water standing in pipe for twelve hours.

SECRET

- (3) Boiler compound and salt water circulating.
- (4) Boiler compound and salt water standing.

None of the boiler compound treatments was effective in removing appreciable amounts of radioactivity.

(g) One contaminated section of copper-nickel salt water piping from LAFFEY and one of steel from BOTTINEAU were cut into 3" test specimens for acid treatment. These specimens were immersed in solutions of 1/2, 3/4 and 1 normal hydrochloric acid, and 1/2 and 2 strength ammonium citrate buffer solution. (Single strength buffer solution is defined as 24 lbs. citric acid and 17 lbs. 28% ammonium hydroxide in 50 gallons of water. Two-strength is the same quantity of chemicals in 25 gallons of water). These showed that the 3/4 and 1 normal hydrochloric acid solution removed all scale, growth and activity in one hour. The 1/2 normal solution required three hours to remove all activity and still left considerable marine growth at the end of this period. The double strength buffer solution removed all activity and marine growth in 8 hours; the 1/2 strength solution removed only 80% of the activity and no marine growth in sixteen hours.

(h) Salt water system, copper-nickel valves of various sizes from LAFFEY were immersed in double strength ammonium citrate. The valves originally showed readings ranging from .008 to .29 R/day (gb). Although most of the activity was removed in one hour, four hours were required before every valve showed a maximum reading less than .01. At that time, readings ranged from .002 to .007 R/day (gb). A similar experiment with nine contaminated steel valves from BENEVOLENCE evaporator brine lines were dipped and scrubbed in a two normal solution of hydrochloric acid. The time required to reduce readings on these valves from .012 gb to background varied from ten to thirty minutes. There was no visible sign of attack by the hydrochloric acid on valves or valve seats.

(i) The entire salt water system of BARTON was filled with a double strength solution of ammonium citrate. Since the buffer solution experiments on LAFFEY had resulted in removing not all activity and only 30% of fouling after seventy-two hours, it was decided to extend the time on BARTON. Unfortunately, from the standpoint of the test, BARTON's salt water lines showed only a few significant readings, but she was the only vessel available for the test at the time. In order to obtain more complete information

SECRET

as to the effectiveness, however, twelve valves in the system were dropped for monitoring before and after the treatment. The maximum reading before the test was .084 R/day gb. The solution stood in the system for 90 hours and was drained. The system was then flushed thoroughly, neutralized with a soda ash solution and reflushed. All previous significant readings were reduced to background; the maximum internal reading at any check point was .007 gb., and all marine growth and scale with the exception of some barnacles in a few spots had been removed by the treatment.

(j) A series of tests was conducted to determine the extent of attack of the solutions being used for decontamination on metals commonly found in salt water systems on naval vessels. The specimens were 1/2 x 3" x 1/16" copper-nickel and medium steel strips, and 3" sections of admiralty metal evaporator tubes. The solutions used were 1, 2 and 5 normal uninhibited hydrochloric acid; 1, 2 and 5 normal inhibited hydrochloric acid; and 1/2, 1, 2 and 4 strength ammonium citrate buffer solution. The specimens were immersed in the various solutions at room temperature without agitation and weighed periodically to determine loss of metal. The results are plotted in detail in Appendix III. In general it was found that 5 normal uninhibited hydrochloric acid would cause medium steel to lose about one ten-thousandth inch of surface in approximately three hours, 2 normal in about five hours and 1 normal in about seven hours. Inhibited hydrochloric acid and buffer solution caused loss of one hundred-thousandth inch or less in six hours in all strengths and on all metals investigated.

34. On 26 September, as a result of the failure of the hydrochloric acid solution to be fully effective in cleaning evaporator shells when filled only to the top of the tube nests, Bureau of Ships Confidential Speedletter, Serial 1383, was promulgated. This speedletter modified the original directive Serial 1381 of 24 September by specifying that evaporators would be filled to as near the tops of the shells as practicable. In addition, stress was laid on adequate safeguards to insure that acid did not enter the fresh water system, and instructions were contained for neutralizing the evaporators by flushing with boiler compound solution and testing the fresh water system to insure that no acid had entered. This serial is included in Appendix IV.

SECRET

35. On the basis of the experimental work conducted at San Francisco Naval Shipyard and the University of California Laboratory, it was now apparent that it was entirely feasible and practicable to remove radioactive matter from the non-target ships. It was recognized, of course, that considerable refinement of methods and techniques were indicated and that selection of best methods would be dependent on further experience and scientific investigation. The next most pressing need which arose, however, was establishment of a standard basis on which it could be determined when a vessel required decontamination and when it could be considered clear after decontamination methods had been applied. The nationally accepted standard of 0.1 R/day for continuous exposure of personnel to gamma radiation had been used as the standard for conduct of operations at Bikini and for restricting movements of personnel on contaminated non-target ships and returning ex-targets subsequent to the tests. Since that time, however, the revelation of the presence of alpha emitters with the fission products, the lack of instruments for detecting alpha emitters and the absence of standards for safe exposure to them had introduced an indeterminate factor in all deliberations as to radiological safety. It is true that a definite ratio of quantity of plutonium to millicuries of fission products present in any particular surface had been established, but the total quantity of alpha emitters to which an individual might be exposed on a ship over a long period of time was the determining factor in safety studies. No ready means for determining this quantity without extended investigations was apparent. Consequently, although .01 R/day had been selected as the arbitrary external radiation intensity below which all salt water systems should be reduced for clearance of active ships, no radiologists of recognized authority were ready to declare this figure safe until a study had been made of all factors involved. The University of California radiologists were of the opinion that the total quantity of fission products which should be considered safe for one ship would vary from 100 millicuries to one curie depending on the size of the vessel and the extent and distribution of the salt water system surfaces exposed to radioactive contamination. Some means would be required for conversion of radiation readings obtained on a ship to indicate whether the activity present was within these limits.

36. On 1 October, a conference was called by Bureau of Ships representatives in San Francisco to discuss the means of establishing

SECRET

limits of radiological clearance of ships and standard procedures for decontamination. All interested agencies in the San Francisco area were represented. Arrangements were made at this time for a closely-knit organization consisting of representatives of the Bureau of Ships, Bureau of Medicine and Surgery, University of California and Naval Shipyard, San Francisco to collaborate on arriving at a solution to the problems with each discharging his own particular functions in an integrated effort. The Bureau of Ships designated ROCKBRIDGE as an experimental ship for the work. This ship offered an excellent specimen because she was the most heavily contaminated vessel to arrive in the area and was of sufficient size and proper type to provide a basis for broad studies of contamination measurement and systematization of decontamination procedures.

37. Complete instructions were issued to the Shipyard for work to be accomplished to permit the University of California to conduct an assay as to the plutonium present on ROCKBRIDGE. Work commenced promptly by drydocking the ship on 3 October. As the water was pumped down in the dock, the underwater body was carefully monitored. A 20 foot square area representing the heaviest radioactivity was selected and designated for a special test. The hull was then allowed to dry thoroughly in order to represent worst possible dust conditions. One foot square areas considered representative of the various conditions found on the hull were selected, carefully monitored, superficially scraped, remonitored, scraped to bare metal and remonitored. The materials thus removed were sent to the University of California Radiation Laboratory for analysis and use in estimating the contamination of the underwater body. Prior to scraping, the selected areas showed readings from .036 to .36 R/day. The designated test area was then sandblasted using regular wet sandblasting procedures. Two blowers with glass wool filters were used to collect as much of the dust as possible. One blower was placed next to the sandblaster and the other on the floor of the dock below. The sandblasting reduced all readings in the test area to background values. The sand on the floor of the dock read .002 - .005 R/day. Samples of the sand together with the filters from the blowers were taken to the University of California for analysis. It was intended that analysis of the filter samples obtained would provide information as to the worst respiratory conditions which might be expected in sandblasting the hull dry without prelimin-

SECRET

ary removal of marine growth. It also was planned to find the total amount of plutonium present on the underwater body by assays of scrapings of representative hull areas and of samples of the sand used in sandblasting.

38. During this period studies also were being conducted at the University of California to determine whether hydrochloric acid was effective in removing alpha emitters as well as the fission products detectable by the geiger counters, and to establish optimum concentrations of acid solutions for use in decontamination work. Research had already revealed that ammonium citrate would take up in solution many fission products and plutonium by offering greater attraction for them than did the marine growths and calcareous structures (phosphates and carbonates) and the rust (hydroxides). With the hydrochloric acid solutions, however, the action consisted of dissolving the calcareous materials and rust which contain the radioactive products rather than taking into solution the products themselves. The acid underwent a chemical change in this operation forming new soluble compounds with the carbonates, phosphates and hydroxides, and liberating carbon dioxide gas. The end result was the same as with the citrate solution, in any case, since the material containing the activity was in solution or suspension and was removed when the acid solution was drained and the system flushed. When using ammonium citrate, a solution of sufficient strength had to be used to compete with the quantity of carbonates, phosphates and hydroxides present. Consequently, it was recommended that full strength solution (24 lbs. citric acid and 17 lbs. ammonium hydroxide to 50 gals. water) be used on ferrous lines and double strength solution (same chemicals in 25 gals. water) on copper-nickel lines. In the use of hydrochloric acid care had to be exercised to insure that sufficient strength of solution was used to avoid complete neutralization which might cause the active materials to reprecipitate. It definitely should be understood that in all cases the treatments used did not affect the radiations emitted by the fission products and plutonium, but merely removed them from the areas affected.

39. The results of the investigations revealed that hydrochloric acid was equally as efficient as ammonium citrate in removing fission products and alpha emitters from salt water systems. Since the

SECRET

inhibited hydrochloric acid was found to attack shipboard materials at about the same rate as the citrate, there was much to recommend the former as the standard decontamination solution. It is more thorough in removing scale and marine growth, it requires much less time to do a complete job (4 hours against 72) resulting in a lesser overall attack on metallic surfaces and saving of time, and the chemicals required are cheaper and more readily available. The principal disadvantage of the hydrochloric acid is the industrial hazard incident to its use which, however, requires only simple and well known precautionary measures.

40. In order to determine the practicability of using hydrochloric acid as a decontaminating agent for an entire ship's salt water system, a 1 normal solution was circulated through the fire and flushing system of WALKER for four hours. The system was then drained, neutralized and flushed thoroughly. The outside readings, which had been as high as .07 R/day, were with only one exception reduced to less than .01 R/day, and in most cases, including pumps and valves, radiation readings were decreased to .001 R/day or less. In addition, the operation had been carried out without undue difficulty. The decision was therefore made to use hydrochloric acid as the standard decontamination material in continuing the experimental work on ROCKBRIDGE.

41. Subsequent to the sandblasting and procurement of samples on the controlled area of the underwater body of ROCKBRIDGE as outlined above, additional samples of barnacle scrapings from eighteen square feet of hull, marine growth from six square feet, and rust from six square feet also were obtained in order to make a calculation of the total quantities of these materials on the underwater body. Finally, the entire remainder of the exterior underwater hull was sandblasted completely and the sand used was sampled statistically and sent to the University of California for assay in connection with the calculations of the total amount of plutonium on the ship. As the next step in the process, all salt water systems in ROCKBRIDGE were completely and carefully monitored throughout. The systems were opened up and samples of the foreign matter obtained at fourteen high reading locations in the fire and flushing system, and at three locations in the evaporators. At each sampling location measurements of the amount of foreign material present and the area represented thereby were determined. Finally, the total areas of all

SECRET

parts exposed to sea water in and on the ship were calculated carefully. The areas calculated included evaporator plant, main and auxiliary condensers, fire and flushing system complete, cooling system and lubricating oil coolers, and exterior hull. All these data, together with the samples obtained, were forwarded to the University of California Radiation Laboratory.

42. The entire firemain and flushing system, excluding the refrigeration cooling system, was filled with a one normal solution of hydrochloric acid. The solution was introduced from a 500 gallon mixing tank through the numbers one and two fire and flushing pumps and recirculated by leading a hose from an after fireplug back to the mixing tank. The circulation was continued for three and one-half hours after the system was completely filled, following which the system was flushed with fresh water, neutralized with a solution of trisodium phosphate and reflushed thoroughly with fresh water. Following this decontamination, a complete remonitoring survey was conducted and the results sent to University of California. Similarly, a 1.4 normal solution of hydrochloric acid was circulated through the evaporators for about four hours, followed by flushing, neutralization and reflushing. As in the case of the fire and flushing system, complete monitoring surveys were conducted before and after cleaning. Monitoring results together with samples of the decontaminating liquids utilized were sent to the University of California. The decontamination processes conducted on ROCKBRIDGE were successful in removing about eighty percent of the radioactive material from the fire main and flushing system and reduced the evaporators to background except for a few isolated spots which required detailed treatment.

43. The data obtained from the ROCKBRIDGE studies were considered sufficient to provide information as to the approximate total quantities of fission products and alpha emitters on board. Since ROCKBRIDGE was known to be one of the most heavily contaminated non-targets, it was assumed that data regarding the actual amount of contamination together with full monitor readings would enable establishment of firm limits for radiological clearance of all non-target vessels. Upon completion of procurement of the necess-

SECRET

any basic information, however, it became obvious that the amount of radiochemical analysis entailed by the project and the limited facilities available for the work at the University of California signalled a period of weeks before final results could be presented. Meanwhile the number of ships released from Crossroads was growing rapidly and many of these vessels could not carry out their operational schedules until clearance had been granted. It must be remembered, also, that no work whatever had been authorized as yet for decontamination of the suspect vessels scheduled for inactivation or disposal. This fact was delaying release of crews and prosecution of necessary work preparatory to assigned disposition. It was apparent therefore that the earliest possible establishment of some standards of clearance and instructions for complying with them was essential. The Bureau of Medicine and Surgery had been charged with the responsibility for assessing radiological hazards and setting safety tolerances by the Chief of Naval Operations in a directive establishing the Navy's radiological safety program on 27 August. (See Appendix IV). However, the Bureau of Medicine and Surgery was helpless because that agency had been able to obtain no safety standards for this type hazard either from previous experience of others or from current investigations. All decisions were based on opinions from the group of radiologists on the West Coast under the guidance of Captain Walsh, the JTF-1 representative. As stated above, Drs. Hamilton and Scott had expressed themselves verbally on several occasions as being of the opinion that .01 R/day would be an acceptable standard for maximum exterior radiation from salt water lines or machinery below which no decontamination would be required, but were not willing to go on record officially as to the safety of this figure until further data became available. It was admitted at the time, however, that the tentative figure mentioned was intentionally low because of consideration of the slight possibility that a large portion of the contamination remaining might accumulate in one spot and thereby produce a hazard, and also because gamma and beta indicators decayed so much more rapidly than alpha emitters that cleaning should be undertaken immediately while easily read indicators were present.

44. On 10 October, the Bureau of Ships addressed a dispatch to Captain Walsh proposing limits for final radiological clearance and decontamination of all non-target vessels including those scheduled

SECRET

for inactivation and disposal. The recommended limits were briefly as follows: (All readings in R/day: g = gamma, gb = combined gamma and beta).

(a) Enclosed in metal or other shielding media.

Final clearance - all readings .01 g. or less.

Clean soon as practicable - 25% or less of readings .01 - 0.1 g.

Clean immediately - more than 25% of readings .01 - 0.1 g or any area exceeds 0.1.

(b) No shielding media interposed.

Final clearance - all readings .02 gb. or less.

Clean soon as practicable - any readings .02 - 0.1 gb.

Clean immediately - any areas reading in excess 0.1 gb. except that underwater hull need not be decontaminated until next scheduled docking.

The dispatch also proposed acid cleaning all evaporators as a precautionary measure regardless of radiological condition and proposed omission of sandblasting of underwater body at first scheduled docking if all readings were less than .02 R/day gb. Captain Walsh was requested to discuss the proposed limits with Drs. Hamilton and Scott and to submit specific recommendations.

45. On 11 October, Captain Walsh, after conference with Dr. Hamilton, submitted the following recommendations by dispatch:

(a) Closed systems such as evaporators, salt water systems, heat exchangers, etc., (external readings).

(1) Final Clearance:

SECRET

Active ships .01 g or less.

Inactive and Disposal Ships .001 g or less.

(2) Clean soon as practicable:

All ships where up to 25% of readings 0.01 - 0.1 g.

(3) Clean immediately:

All ships where over 25% of readings 0.01 - 0.1 g or any section exceeds 0.1 g.

(b) No shielding media as on hull:

(1) Final Clearance:

Active Ships .05 gb or less.

Inactive and Disposal Ships .005 gb or less.

(2) Clean soon as practicable:

All ships with readings 0.05 - 0.5 gb.

(3) Decontaminate immediately:

All ships any area reading over 0.1 g (except underwater body).

(c) Underwater Body.

(1) No sandblasting but remove fouling using wet technique:

All ships with all readings .05 gb or less.

(2) Sand blast at first scheduled docking:

SECRET

All ships if readings exceed 0.05 gb.

(3) Sandblast immediately:

All ships where readings taken on inside of hull exceed 0.1 g.

As an item of information, Captain Walsh's dispatch advised that the lower limits were recommended on inactive and disposal ships for medico-legal and security reasons.

46. The Bureau of Medicine and Surgery was opposed to acceptance of the two standards of clearance proposed by Captain Walsh. The basis of the argument on this point was the fact that ships currently scheduled for the active fleets might at a later date be transferred to inactive or disposal status. A change in status of this nature would require that vessels so transferred be reduced to tolerance levels established for ships scheduled for inactivation or disposal. Since this change might take place long after the gamma and beta indicators had decayed beyond the level of detection by readily available instruments, the only method remaining by which alpha contamination could be determined would be difficult and extensive sampling and radio-chemical analysis. In view of this fact, the Bureau of Medicine and Surgery considered that final clearance standards must be the same for all ships and that any preliminary clearance granted active ships and considered acceptable for normal operation and repair but not for inactivation or disposal, must be recognized as such. Therefore, it was ruled that final clearance maximum allowable readings for all ships would be .001 R/day gamma for shielded readings and .005 R/day combined gamma and beta for exposed surfaces pending further developments.

47. It was obvious to the Bureau of Ships that reduction of all readings on salt water systems even to .01 R/day gamma would require decontamination of almost every non-target which had been exposed more than one day in the lagoon after test Baker. Those which had been exposed only one day were found to be within the limits of .001 R/day and were granted final radiological clearance immediately along with all vessels which had not entered the lagoon subse-

SECRET

quent to Test Baker. From the success of experimental work to date in decontamination at San Francisco, it was considered that sufficient experience warranted the adoption of the best methods already developed as standard for all ships requiring decontamination. Consequently, the Bureau of Ships, with the concurrence of the Bureau of Medicine and Surgery, promulgated a dispatch on 14 October (141550Z, copy included in Appendix IV) authorizing the ship's force of all non-target vessels, including those scheduled for disposal and inactivation, to proceed immediately with acid cleaning of evaporators in accordance with previous letters, and also one acid cleaning of the entire firemain, flushing, cooling and drainage systems, including pumps, coolers and other heat transfer apparatus except condensers. The solution prescribed was about 1.1 normal, inhibited hydrochloric acid in fresh water. As an additional measure, boiling out of the salt water sides of main and auxiliary condensers with boiler compound was prescribed in accordance with the procedures set forth by the Bureau of Ships Manual for cleaning the steam sides of condensers. In the dispatch also were included statements to the effect that special protective clothing was not required for work on non-target vessels and the only real restriction was avoidance of skin contact with radioactively contaminated surfaces. The reason for stressing this point lay in the fact that considerable confusion still existed in many minds as to how much protection was required for personnel on the non-targets. This matter had not been amplified sufficiently in the original directive.

48. On the basis of authority contained in the dispatch of 14 October, necessary decontamination work was initiated by ship's force in the majority of the Bikini non-target vessels not already granted final clearance. About fifty-five of the ships involved had arrived on the West Coast and work proceeded as well as might be expected considering the fact that personnel were dealing with an entirely new field. Many questions as to details of application to particular ships arose. To answer the inquiries and requests for indoctrination, the Bureau of Ships maintained officer representatives on the West Coast constantly. These officers visited from time to time all industrial activities and type commanders who were handling contaminated vessels as the need arose for clarification of details. The specialist officers so assigned were sorely pressed to find time to provide sufficient details to all ships seeking information. The need for a detailed directive was apparent, but it was desired not to promul-

SECRET

gate a general document of this nature until clearance limits had been established and until prescribed procedures had proved definitely satisfactory in a number of cases. It was considered that premature issue of information which required considerable revision at a later date would possibly harm the program more by engendering confusion than would instruction of ship crews by only a few officers well familiarized with the problem and the investigations in hand, and who were in close contact with the Bureau of Ships. The need for detailed written instructions was alleviated partially by preparation and distribution of the most up-to-date information on approved decontamination methods by the Bureau of Ships representatives to vessels arriving on the West Coast.

49. In order to permit further development of decontamination methods, provide further information as to nature and extent of contamination on various types of vessels exposed in Bikini lagoon, and to make available further data as to quantities of radioactivity and fission products on board non-target vessels, ACHOMAWI (ATF-148) and LST 881 were ordered to Naval Shipyard, San Francisco for experimental decontamination. It was anticipated that controlled monitoring and cleaning of these vessels, combined with careful sampling, would produce data required to supplement findings on ROCKBRIDGE. Preliminary data from the studies on ROCKBRIDGE were becoming available and it was already obvious that data obtained were incomplete in many cases and in general were indicative only of the worst conditions to be found in the ship. Hence, they were of doubtful value for integration in an effort to determine accurately the total quantities of fission products or plutonium aboard. In general, however, the experimental work at San Francisco had decreased considerably and greater emphasis was being placed on accomplishment of decontamination by methods already developed pending final outcome of the ROCKBRIDGE studies.

50. The lack of designation of a military authority charged with responsibility of actual prosecution of decontamination work on the non-targets had not been remedied. Consequently, the Bureau of Ships requested the Commander in Chief Pacific and Commander Western Sea Frontier to direct ships under their operational control to apply the authorized measures as soon as possible and compatible with operational schedules. Most of the work with the exception of drydocking was

SECRET

within the capacity of ship's force. Controlled experiments in complete decontamination by ship's force at sea were conducted in the San Francisco area and were most successful. Some limited assistance was required in obtaining acid mixing tanks and miscellaneous items of equipment to accomplish the acid circulation. This aid was provided for by the Bureau of Ships in authorizing any Naval industrial activity to expend up to one thousand dollars per ship in rendering essential shipyard services to vessels in accomplishing decontamination work. A section had been established as Code 180-A under the Director of Ship Material in the Bureau of Ships to coordinate and provide necessary technical direction for decontamination and clearance of ex-Crossroads vessels. This section was made up entirely of officers who had participated in the material aspects of the Bikini operations and who were thoroughly familiar with the radiological problems involved and the methods developed to combat them.

51. Although considerable inertia was usually experienced at the outset, the decontamination program by ship's force on the West Coast gradually swung into action. Many of the ships with the assistance and guidance of the various groups organized for the purpose were meeting with considerable success in removing radioactive material from the salt water systems. On the advice of Captain Walsh, the limits originally recommended to the Bureau of Medicine and Surgery for final clearance of active ships were adopted as the temporary standard for "operational", "conditional" or "preliminary" clearance as it was variously termed. In order to relieve obvious confusion as to the implication of this type of radiological clearance, the Bureau of Ships defined it as clearance for all normal operations, maintenance and repair subject only to the previous restrictions imposed on skin contact with radioactive surfaces and exposure to dust from dry abrasion. It was recognized that final clearance limits could not be definitely fixed until the data from ROCKBRIDGE assays had been compiled.

52. In addition to the establishment of criteria for determining when vessels had been decontaminated completely, two outstanding gaps appeared in the decontamination processes thus far authorized. The first was the question of establishing when underwater body decontamination was necessary and the second was the development of

SECRET

an effective method for removing activity from condensers. Boiling out of condensers with boiler compound solution had yielded negligible results. With respect to underwater bodies, the Bureau of Medicine and Surgery was not convinced that the recommended limit of .05 R/day gb for clearance of the exposed exterior hull below the water was compatible with the .005 R/day gb recommended for other exposed surfaces. The Bureau of Ships, on the other hand, was desirous of developing some means of determining without drydocking whether the underwater hull required decontamination. The docking of vessels was an expensive and time consuming operation which should be eliminated entirely, if possible, without violating safety or security considerations.

53. The first preliminary reports of the results of the ROCKBRIDGE assays conducted by the University of California indicated that the total quantity of fission products present was just about a tolerance dose if the samples taken were considered as representative of conditions over the entire bottom. This conclusion was most encouraging to the Bureau of Ships since some of the samples taken had read as high as 0.4 R/day and the average was about 0.2 R/day. This finding, if confirmed, would eliminate the necessity for underwater body decontamination of most if not all of the non-target vessels. How to determine without drydocking whether a vessel met the prescribed conditions, however, was not readily apparent. Two possible schemes were devised. The first was correlation of readings inside the hull with conditions of radioactive contamination existing outside. This, however, proved to be impracticable because of the low order of activity being dealt with. The second possible solution lay in listing the ships and monitoring carefully the portion of the underwater body thereby exposed. It was known from experience on hulls already drydocked that the radiological conditions on the underwater hull in the vicinity of the waterline were generally representative of the worst conditions found anywhere on the underwater body. Immediate steps were taken, therefore, to have suspect vessels in all ports of the West Coast listed and monitored at the waterline. The encouraging aspect of the underwater contamination was the established fact that the plastic types of paint did not contain more than trace quantities of fission products. All of the contamination resided in any marine growth and rusty or scaly patches present.

54. Representations were made to the Bureau of Medicine and Surgery to decide whether the method of determining the condition

SECRET

of the underwater body of the suspect ships by listing and monitoring portions of underwater bodies thus exposed would be satisfactory for clearance purposes. That Bureau did not desire to render a decision on any matter involving ship clearance without further advice on each question by a competent board of radiological advisors. On 25 October the Bureau of Medicine and Surgery consequently authorized establishment of a special medical advisory board to counsel the Chief of the Bureau of Medicine and Surgery on radiological matters. (See Appendix V). The board consisted principally of recognized radiologists and radioactivity toxicologists: Drs. Hamilton, Scott Rodenbaugh, Newell, and when available, Drs. Langham and Stafford Warren. Captain Walsh was designated chairman and Lieutenant (jg) Morton as recorder of the Board. The duty assigned this Board was to consider and make recommendations to the Surgeon General of the Navy on radiological matters specifically presented to it for study. The first series of problems presented dealt with the many aspects of radiological clearance of ships which had been matters of controversy during the preceding weeks.

55. The Medical Advisory Board to the Chief of the Bureau of Medicine and Surgery held its first general meeting on 4 November. At this conference the data from ROCKBRIDGE studies were made available to members of the Board. On the basis of this information and after considerable discussion, the following general final clearance limits were recommended: (All readings R/day, g = gamma, gb = combined gamma and beta.

Shielded

Active Ships .01 g max.

Inactive and Disposal .001 g max.

Unshielded

Active Ships .05 gb max.

Inactive and Disposal .005 gb max.

SECRET

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Underwater Body

Active Ships .05 gb.

Inactive and Disposal .02 gb.

In addition, the Board made the following comments:

(a) When readings are below tolerance except for one localized area on hull, each case to be considered on its own merits.

(b) For evaporators and pipes, all sections should be cleaned to below tolerance except sections outboard of the sea valves which should be considered part of the hull.

(c) More experience is required before a statistical average of readings with no single area above a certain intensity can be specified as satisfactory from the standpoint of quantitative degree of radioactive contamination of a ship.

(d) On the basis that ROCKBRIDGE underwater body is the worst to be expected, recommend that tolerances specified be met prior to granting clearance.

(e) Waterline readings are considered of no value as an indicator of the general condition of the underwater body. They may be of value if ships are heeled over. It is recommended that an attempt be made to correlate internal and external hull readings from experience gained on ships drydocked.

(f) The X-263 is unsatisfactory for reliable readings below .01 R/day, but is the best available instrument and can be used if calibrated on known radium sources.

56. The Bureau of Medicine and Surgery immediately took exception again to the application to active ships of radiological clearance standards differing from those specified for inactive and disposal ships, because of the possibility of change in ultimate assignment as discussed previously. The Bureau of Ships declared that it was not practicable nor considered necessary to decontaminate the entire salt-water system of a ship to the prescribed standard of .001 R/day for external radiation readings. There was also considerable question as to the interpretation of .02 R/day as the limit for underwater body clearance; i.e., whether this was a maximum or statistical average and whether readings were to be taken with hull wet or dry.

SECRET

57. The University of California report on the investigations conducted on ROCKBRIDGE had estimated that there was sufficient plutonium on the ship to constitute several tolerance doses. The findings indicated that most of the radioactivity was in the salt water piping systems. The quantity of plutonium estimated on the underwater body from the samples analyzed would constitute about a tolerance dose if concentrated. In this case, however, the material is so widely distributed in tons of rust, scale, paint, marine growth and other matter that it would represent a remote security and a negligible physiological hazard. Further, when removed by sandblasting, the plutonium would be mixed with some 125 tons of sand and would present absolutely no hazard of any type. The report on the ROCKBRIDGE was recognized as representing the integration of worst conditions throughout the ship, and the Bureau of Ships did not consider it representative of the actual conditions on this or any other ship and argued that it should be taken in that light when establishing clearance limits. The Medical Advisory Board apparently had used the report as an example of what might be expected on a ship with monitor readings on the order of those on ROCKBRIDGE and recommended final clearance limits accordingly. The report had many discrepancies and points requiring clarification. The Bureau of Ships took immediate steps to insure that a more exact determination of fission products on board and proper coordination with radiation readings would be obtained from the assays to be conducted on ACHOMAWI (ATF-148) and LST 881. It was realized, however, that it would be many weeks before these data could be made available and that the ROCKBRIDGE report would have to be used as authoritative until further information of a positive nature was forthcoming.

58. Dispatches were sent concerning some of the questions arising on the Medical Advisory Board recommendations, and a Bureau of Ships representative, Commander J. J. Fee, USN, proceeded to the West Coast to discuss the matter further. After additional study and consultation with the Bureau representatives, the Board revised its recommendations for final radiological clearance of all ships as follows, all readings in R/day corrected to 1 October 1946:

(a) For all units which are habitually closed, shielded readings as follows:

SECRET

(1) Ninety-four percent of ship's salt water system not exceeding .001 gamma.

(2) Five percent of salt water system not exceeding .005 gamma.

(3) One percent of ship's salt water system not exceeding .01 gamma.

(b) Open systems limited to average .001 gamma and .005 combined beta and gamma.

(c) Underwater body, statistical average of readings systematically taken not exceeding .02 combined gamma and beta wet or dry on portions of underwater body exposed by listing and trimming to maximum practicable extent.

The Board at this time advised the Bureau of Ships that the desirability of one set of standards for all ships had been recognized, but that two categories had been recommended originally in an attempt to effect early release of active ships for operational purposes. The Board considered that the amount of activity allowable for active ships was much greater than for ships being scrapped and that active ships later designated for scrapping could meet disposal standards at a later date if required.

59. The Bureau of Medicine and Surgery accepted the revised recommendations for final clearance, and established the operational or preliminary clearance standards at the values recommended previously by the Board for active ships. These limits were accepted by the Bureau of Ships as workable and it now became possible to put ship clearance on a sound basis and to advise vessels specifically what additional cleaning would be required to meet standards. The final step lay in furnishing to all ships involved a general detailed directive including clearance procedures, clearance limits and detailed instructions for decontamination of each part or system of a ship showing radiation intensities exceeding tolerance levels.

60. During the period of controversy regarding clearance standards, further experimental work on removing radioactivity from main and auxiliary condensers was carried out at Naval Shipyard, San Francisco. The circulation of 1/2 normal hydrochloric acid solution was tried in several auxiliary condensers and proved effective in

SECRET

condensers which were copper-nickel throughout. The treatment removed only about 50% of the activity in condensers which had dissimilar metals in heads, tube sheets and tubes. Because of the heavy deposit of scale and rust on the heads in the latter type it was necessary to submit them to more thorough treatment. After several variations in methods it was found that the most efficient general method of cleaning lay in submitting the entire condenser first to a one-half normal acid treatment for one hour, then opening up and cleaning manually in detail any parts remaining above tolerance. The manual cleaning consisted in the main of wire brushing thoroughly the inside of the heads with a one-normal acid solution, punching the tubes with a rag and rod, removing all scale and sludge and flushing down thoroughly. This treatment had no ill effects on the condenser materials and was considered satisfactory for adoption as standard. The use of acid in main condensers was not considered acceptable because of the large size and the possible damage from electrolytic action between dissimilar materials. Main condensers in most cases were contaminated only lightly, and removal of zincs followed by detailed manual cleaning of heads, tube sheets and tubes, removal of sludge and scale, and thorough flushing proved satisfactory.

61. Upon completion of the experiments on condensers and the establishment of clearance limits, the Bureau of Ships representatives on the West Coast prepared a complete set of proposed instructions for decontamination of all parts of non-target ships found radioactive beyond clearance limits, and detailed safety precautions to be observed in the work. These were returned to Washington, some additional data included by the Bureau of Medicine and Surgery and issued jointly on 22 November by the Bureau of Ships and Medicine and Surgery. A copy of the letter is included in Appendix IV. This letter superseded all previous instructions and served as the established doctrine for radiological decontamination and clearance of all remaining contaminated Crossroads non-target vessels.

62. Using the ship clearance and decontamination procedures established by the letter of 22 November, the ship's force of all contaminated vessels, except those prevented by operational requirements from doing so, continued with decontamination in accordance with the established doctrine. At this time many vessels already had

SECRET

been cleared. At each opportunity radiological monitors made surveys of the parts of ships not yet cleared and requiring decontamination and forwarded reports of findings on forms provided. Operational clearances were granted as rapidly as possible by Commander Western Sea Frontier and final clearances by the Bureau of Ships and Bureau of Medicine and Surgery upon reduction of readings to specified limits. By 1 January 1947, a total of 80 vessels of the 159 non-targets had been granted final radiological clearance, and work was progressing favorably on most of the remainder.

63. In many cases the prescribed circulation of the hydrochloric acid solution was not completely effective in reducing radioactivity to tolerance levels in all parts of salt water systems. Particular difficulty was encountered in dead ends of piping systems or where circulation was poor, such as in by-passes at reducer stations. Some trouble was also experienced in firemain gate valves where valves were installed with bonnets down allowing silt, rust and marine growth to be pocketed in the bonnets where acid solution circulation could not remove it. The ultimate success in all cases of this nature depended on the energy and initiative of the ship's force. Where general circulation failed, the obvious solution to the problem was removal and manual cleaning of the part involved, or isolation of a particular section for detailed acid solution treatment.

64. On 27 November, a conference was held in the Bureau of Ships for the purpose of discussing the overall situation with regard to safety and security of the radiological decontamination procedures on the Bikini non-target ships. Attending the conference were representatives of Bureau of Ships, Bureau of Medicine and Surgery, Manhattan Engineering District, and Dr. J. G. Hamilton of the University of California, J. G. Crocker Radiation Laboratory. The conclusions reached at the conference were as follows:

(a) There is absolutely no possibility of physical injury from radioactive materials in the amounts being dealt with on the non-targets under existing conditions.

(b) The possibility of the use of radioactive materials removed from non-targets as a source of plutonium need be of no concern because it is much easier and simpler to produce larger amounts by use of small cyclotrons which are more readily available.

SECRET

(c) The principal question of security lies in the possibility of determining bomb efficiency by analyzing radioactive products removed from ex-Crossroads vessels. When decontaminated to existing limits for final radiological clearance the only possible source for this analysis would lie in materials removed from the underwater body. Even this was considered to be impossible, but Dr. Hamilton agreed to conduct analyses of these materials to determine whether successful determination of efficiency by this method was possible. Manhattan security personnel agreed that, pending receipt of information to the contrary, underwater bodies of non-targets cleared according to existing standards would be considered as presenting no security hazard.

(d) Special disposal of sand used in sandblasting underwater bodies of radioactively contaminated non-target ships is not required, provided marine growth is removed first and disposed of.

(e) Solutions used in removal of radioactivity from salt water systems of non-target ships may be discharged into harbors, preferably at a slow rate or after dilution, without security or health hazard.

The minutes of the conference are included in Appendix V. The information regarding disposition of sand-blasting sand and decontaminating solutions was promulgated to all interested commands and appropriate corrections to the procedure letter of 22 November were issued. Included also in this correction, which is contained in Appendix IV, were approved recommendations of the Medical Advisory Board that small boat hulls, anchor chain, anchors and chain lockers be subject to the same limits for final radiological clearance as were underwater bodies of non-target ships.

65. On 18 December, information from tests conducted at the University of California revealed that the decay rate of gamma radioactive material had been found much more rapid than was originally realized. The tests revealed that readings taken on 1 December 1946 to be corrected to 1 October 1946 would require application of a factor of two. This was of considerable importance since the required factor had been calculated previously as 1.1 - 1.2, and had been neglected because it was within the range of error of the instruments used. Many ships had thus been granted final radio-

SECRET

logical clearance when application of proper factors would not have justified it on the basis of established clearance limits. The matter of clearance limits was immediately restudied by Dr. Hamilton of the University of California. His studies on the basis of current information indicated the following:

(a) Limits could be raised considerably without incurring a health hazard.

(b) If geiger counter readings were corrected to 1 January 1947 and existing limits for final clearance maintained, no security hazard would arise.

Existing instructions were modified immediately to require correction of monitor readings to 1 January 1947 for clearance purposes. At the present time it appears that all non-target ships will have received final clearance by about 15 March 1947.

66. The following conclusions are submitted as a result of the experience gained in dealing with radiological conditions on the Crossroads non-target vessels:

(a) Vessels steaming or anchored for even limited periods in sea water containing radioactive atomic fission products will have radioactive materials deposited on all surfaces exposed to the contaminated water. The quantity of fission products deposited will vary with the concentration of radioactivity existing in the sea water, the length of exposure and the physical and chemical properties of the surfaces exposed. The radioactive products deposited will be concentrated principally in exposed matter of vegetable origin, porous surfaces, rust, scale, marine growth and paints other than intact, plastic antifouling paint.

(b) Deposits of radioactive material on shipboard surfaces represent a potential physiological hazard to personnel in two possible ways depending on the quantity and concentration of the fission products.

(1) External radiation effects may be suffered from gamma rays for a variable period by personnel habitually in the vicinity of concentrations of radioactive materials.

SECRET

(2) Internal radiation effects may be experienced by personnel who permit extensive ingress of long-life fission products to their bodies through cuts and abrasion in their skin, or by breathing or otherwise ingesting large quantities of dust generated from radioactively contaminated surfaces.

(c) Natural decay will eliminate personnel hazard from external radiation in a period of time varying from a few hours to several months depending on the degree of concentration. Natural decay does not, however, remove the danger of the long life fission products whose toxicity depends on their introduction into the body.

(d) Application of special fission product removal techniques is required to eliminate from radioactively contaminated surfaces the early gamma radiation hazard and the long-life fission product toxicity danger. The nature and extent of the external physiological hazard produced by gamma radiation is reasonably well defined and readily assessable by available field instruments. The toxicity resulting from the absorption or ingestion of a given quantity of alpha emitter fission products by the human body is not known with any degree of certainty, nor is the ratio of the alpha emitters retained by the body to the quantity introduced. Further, there is available at present no ready means of determining easily and quickly in the field the concentration of alpha emitters in a radioactively contaminated surface.

(e) After two months experimental work, methods were developed which were successful in removing deposits of fission products to the extent necessary to eliminate all health and security hazards from this source. The methods adopted are not suitable for effective field application in early and rapid removal of radioactive contamination since they are slow, tedious and require quantities of material and equipment not ordinarily carried on board naval vessels.

(f) For purposes of national security it is considered necessary that an extensive program of radiological research and development be carried out with the following objectives:

(1) Develop methods of reducing or eliminating deposits of radioactive materials on ship components exposed to water containing products of atomic fission.

SECRET

(2) Develop on a high priority basis means of removing or neutralizing rapidly in the field fission product deposits immediately after an attack utilizing atomic fission.

(3) Develop positive information as to the toxicity from introduction of a given quantity of long-life fission products into the human body by various means, the manner in which such quantities can be introduced, and means for detecting readily the existence and concentration of alpha emitters in any contaminated area.

SECRET

PART III

FUTURE RADIOLOGICAL DECONTAMINATION RESEARCH PROGRAM

1. Early findings of the Crossroads Tests indicated without question that one of the most important and far reaching effects was the contamination of the participating targets by deposits of radioactive materials on the ships and the radiological effects resulting therefrom. As pointed out in Section I of this report, the contamination by alpha emitters, whose concentration can be determined positively at the present time only by elaborate and lengthy radio-chemical analysis, necessitated that attempts to rehabilitate the ships at Bikini be abandoned because of the potential physical hazard involved. Very little was known at the time or, indeed, at this writing, as to the physiological effects of continuous exposure of personnel to the radioactive products on the targets. The same applies to the means of protecting personnel working on ships heavily contaminated, or methods of removing rapidly general concentrations of radioactive materials from ships.

2. The implications of radiological effects on ships exposed in the vicinity of fission of an atomic bomb brought out by the Bikini operations were tremendous. Here was revealed the possibility of killing or disabling, permanently or temporarily, by a single bomb large numbers of men on naval vessels at a distance of three or more miles from the point of fission. Furthermore, large numbers of ships could be rendered unsafe for habitation for indeterminate periods under present standards of ship design and with the present status of knowledge as to the behavior of radioactive products of the bomb. It was clear that a research program of indeterminate scope, but certainly extensive, to obtain and analyze carefully all possible radiological data on the Crossroads target vessels and to develop counter-measures and defense procedures was necessary for future national security.

3. On 27 August 1946, the Chief of Naval Operations promulgated a directive (See Appendix IV) establishing the Navy's Radiological Safety Program. Among other items, the Bureau of Ships was charged

SECRET

in the program with the responsibility for and cognizance over individual and collective protection of shipboard personnel from radiological effects; development of decontamination measures and distribution of decontamination equipment; and development, procurement and distribution of adequate detection instruments. To implement the research program required to discharge the responsibilities assigned to the Bureau of Ships with respect to the Radiological Safety Program, arrangements were made for the return of many of the surviving Crossroads target vessels to Naval Shipyards for radiological studies and other purposes, while several other vessels were scheduled for indefinite retention at Kwajalein for the same purpose. The present plan of geographical disposition of the targets involved is as follows:

SAN FRANCISCO

INDEPENDENCE (CVL 22)
CRITTENDEN (APA 77)
GASCONADE (APA 85)

BREMERTON

PENSACOLA (CA 24)
SALT LAKE CITY (CA 25)
HUGHES (DD 410)

MARE ISLAND

CONYNGHAM (DD 371)
SKIPJACK (SS 184)
SKATE (SS 305)

PEARL HARBOR

NEW YORK (BB 34)
NEVADA (BB 36)

KWAJALEIN

MUGFORD (DD 389)
MAYRANT (DD 402)
RHIND (DD 404)
STACK (DD 406)

BRISCOE (APA 65)
BRULE (APA 66)
DAWSON (APA 79)
FALLON (APA 81)
YOG 83

4. To coordinate the radiological investigation of target vessels and to provide a centralized agency staffed with adequate scientific personnel and furnished with proper equipment to conduct necessary radiological research and development work, the Bureau of Ships directed, on 18 November 1946, that a Radiation Laboratory be established at Naval Shipyard, San Francisco. A copy of the

SECRET

directive establishing the Laboratory is included in Appendix VI. The Laboratory was charged under the Bureau of Ships with making provisions for estimation of radioactive contamination, development of methods and procedures for decontamination studies of contamination by radioactive materials and allied investigations. The facilities so established were designed to supplement and cooperate with activities of the Naval Establishment having direct cognizance of other phases of the radiological safety program. Arrangements were made at the outset for use of the facilities of the Laboratory by the Bureau of Medicine and Surgery for making studies of physical radiological hazards and such work in connection therewith as is associated with decontamination. The Bureau of Yards and Docks and the Bureau of Aeronautics also expect to utilize the facilities of the Laboratory in connection with their problems and responsibilities in connection with radioactivity and radiological safety.

5. The first projects of the new Radiation Laboratory involved studies of the decontamination and final radiological clearance of the remaining non-target vessels. More extensive and complete research work was contemplated for the returning target vessels. The first prospectus of work on these ships was issued on 14 January 1947. A copy is included in Appendix VI. As originally contemplated, the Laboratory will play the major part in portions of the investigation of the returning targets dealing with deposits of radioactive materials on the ship, radiological hazards and decontamination.

6. At the present writing the Radiation Laboratory at Naval Shipyard, San Francisco has just commenced functioning and time has not yet permitted development of extensive information. It is anticipated, however, that the Laboratory will render invaluable assistance in solving future problems involving the use of atomic energy and radioactive materials in warfare and for industrial purposes.

SECRET

APPENDIX I

REPORTS OF TARGET VESSEL
DECONTAMINATION

APPENDIX I

REPORTS OF TARGET VESSEL
DECONTAMINATION

APPENDIX I

FOREWORD

1. The ships' forces which were engaged in decontamination work aboard are as follows:

U.S.S. SALT LAKE CITY (CA25)
U.S.S. NEW YORK (BB34)
U.S.S. NEVADA (BB36)
U.S.S. PENNSYLVANIA (BB38)
U.S.S. PRINZ EUGEN (IX300)
U.S.S. CARTERET (APA70)
U.S.S. WAINWRIGHT (DD419)
U.S.S. CONYNGHAM (DD371)
U.S.S. MUGFORD (DD389)
U.S.S. PARCHE (SS384)
U.S.S. DENTUDA (SS335)
U.S.S. TUNA (SS203)
U.S.S. SKATE (SS305)
U.S.S. SEARAVEN (SS196)

The U.S.S. NIAGARA (APA87) is not included as an example of orthodox decontamination but rather because of the interesting nature of the ship's contamination which necessitated rather different procedures. The following ships found similar conditions and took more or less similar measures upon reboarding and rehabilitating their vessels:

U.S.S. CORTLAND (APA75)
U.S.S. GENEVA (APA86)
U.S.S. SLADEN (APA63)
U.S.S. FILLMORE (APA83)

The ships' reports that are included herein are typical ones and selected on account of the phases of rehabilitation reached. The SALT LAKE CITY had removed most of the numerous "hot" spots and was just about ready to start general decontamination. The U.S.S. NEW YORK had a start on general decontamination. This ship was fortunate in having relatively few excessively radioactive areas to reduce. The U.S.S. WAINWRIGHT made extraordinary good progress toward rehabilitation.

SECRET

CA25/49-7

U.S.S. SALT LAKE CITY

15-che

Serial: 225

19 August 1946

From: The Commanding Officer.
To: The Commander Task Group 1.2.
The Director of Ship Material.

Subject: Report of Radiological Decontamination of the
U.S.S. SALT LAKE CITY (CA-25).

References: (a) CTG 1.2 despatch 171836 of August 1946.
(b) DSM verbal request of 16 August 1946.

Enclosures: (A) Report of Radiological Survey - Post-Baker (nine
(9) pages).
(B) Diagrams of main deck and communication deck
showing radiological areas (six (6) pages).
(Not available)

1. The first efforts at decontamination were begun on 2 August. Thorough cleaning and removal of paint could not be accomplished until 6 August when cleaning materials became available. Four monitors assigned to work with the ship conducted surveys about the ship to determine hot areas the first two days to facilitate the removal of the hot areas first.

2. On 5 August a complete survey was begun and readings on representative areas were recorded. Each day the same route was followed and readings recorded to determine changes. Enclosures (A) and (B) are the results of this survey. Many localized hot areas which were quickly removed are not shown in the record in all cases since they were located by other monitors checking over areas to be worked. Each day new "hot spots" were discovered which were not previously known to exist.

SECRET

Page 69

D 32602

U.S.S. SALT LAKE CITY

15-che

CA25/49-7

Serial: 225

19 August 1946

3. On 5 August a strong acetic acid solution was applied to a deck area on the open bridge to determine the value of acid in decontamination. The 4 ft. square area was scrubbed for 5 minutes after acid was applied then flushed off. A control area of the same size was also scrubbed for 5 minutes using only salt water. Both areas were reduced exactly the same amount (1.5 R to 1.3 R).

On 6 August a similar solution of Hydrochloric Acid was applied to a steel plate and scrubbed for several minutes then flushed off. No control area was used but the results were very nearly the same as for the acetic acid.

On 7 August a piece of the wood deck was removed from the well deck after measuring the radiation of the area. The section was then brought to the ROCKBRIDGE and planed down with a joiner machine by 1/16 inch cuts. 5/16 inch was removed to bring the wood to tolerance. A special report of the experiment was submitted on 8 August.

4. Every effort was made to prevent anyone from receiving more than the established radiation tolerance. It was found necessary to continually caution men about precautions to be taken around hot areas and still some would be found handling debris with bare hands although rubber gloves were available. Men were worked in groups with one petty officer to every 5 or 6 men. It is considered highly impractical to work the SALT LAKE CITY with great numbers of men and remain within safe radiation tolerance without competent petty officers assigned to each small group of men (5 or 6 men).

5. The following is a summary of work accomplished each day.

SECRET

U.S.S. SALT LAKE CITY

15-che

CA25/49-7

Serial: 225

19 August 1948

2 August

A few personnel boarded the ship from the CONSERVER which was moored alongside and sprayed boiler compound and lye solution on bulkheads, the top of turret #1 and the steel deck on the forecastle. Small parties threw numerous pieces of shrapnel overboard from weather decks. Entire ship was hosed down by CONSERVER for about 30 minutes. Average radiation 3 to 4 Roentgen on weather decks except forecastle which averaged about 2 R before work was begun. No readings were taken upon securing.

3 August

Boarded with two parties of 50 men each in 2 hour relays.

Scrubbed forecastle, communication deck and well deck with sand and soap. No other cleaning materials were available. Forecastle readings reduced to 1 R, with steel deck about .5 R.

4 August

Boarded with 3 parties of 50 men each in 2 hour relays.

Holy stoned forecastle with soap and sand. Flushed coral sand (highly radioactive) from open bridge, pilot house level, communications deck and entire main deck. No other cleaning materials were available. Open bridge and pilot house reduced from about 12 R to 4 R average. Some drains and puddles remain high but were removed later.

5 August

Boarded with 3 parties of 50 men each in 2 hour relays.

Cleared away wood gratings, bunting and other debris from open bridge, scrubbed deck and hosed it down thoroughly. Scrubbed

SECRET

U.S.S. SALT LAKE CITY

15-che

CA25/49-7

Serial: 225

19 August 1946

pilot house level, communication deck and flushed down. Flushed down well deck, after superstructure deck and main deck aft. No caustic cleaning materials were available. Average readings on bridge and pilot house reduced to 2.5 to 3 R and communication deck to about 2 R.

6 August

Boarded with 3 parties of 50 men each in 2 hour relays.

Sprayed lye solution on bulkheads and deck of open bridge, pilot house level, turret #1, communication deck and fore-castle deck. Flushed off lye solution after scrubbing with deck scrubbers, removing several coats of paint from painted surfaces. Readings generally reduced 10 to 15% on wooden deck. Painted surfaces reduced 25 to 35%.

Removed vent cover port side, frame 100, main deck. Reading outside--60 R, reading inside--100 R. Flushed out vent with hose. Reading reduced to 8 R.

7 August

Boarded with 3 parties of 50 men each in 2 hour relays.

Holy stoned main deck from fore-castle to well deck. Sprayed lye solution on bulkheads from turret #1 to the well deck. Lost electric power at 1400. Unable to washdown scrubbed decks.

Cleaned out contaminated newspapers and canvas from wing storage frame 60. Readings reduced from 48 R to 4 R.

Cleaned out debris from spud locker and flushed out. Reading reduced from 32 R to 10 R high with about 5 average.

SECRET

U.S.S. SALT LAKE CITY

15-che

CA25/49-7

Serial: 225

19 August 1946

8 August

Boarded with 2 parties of 80 men each in 3 hour relays to reduce time lost in changing working parties.

Completed flushing loose paint from areas where solution was applied previous day.

Solution had to be reapplied to remove paint. All bulkheads and turrets in forward half of ship were completed. Commenced spraying and flushing of bulkheads on after superstructure deck. Considerable paint was removed although reduction in general radiation was about 10%. Where paint collected in puddles around drains on communication deck reading increased from 1.5 R to 5 R. Puddles were removed.

9 August

Boarded with 2 parties of 80 men each in 3 hour relays. Removed hot debris from after searchlight platform. Removed pockets of hot sand and debris in airplane crane structure and around structure abaft after stack.

Removed paint with lye solution from turret #3 and #4, secondary conn structure and gun shields, on after superstructure deck. Slight reduction in radiation apparent although a complete survey was not made after completion of work and the ship was not again boarded for the regular daily survey conducted each morning.

J. CONNOR

SECRET

Page 73

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U.S.S. SALT LAKE CITY

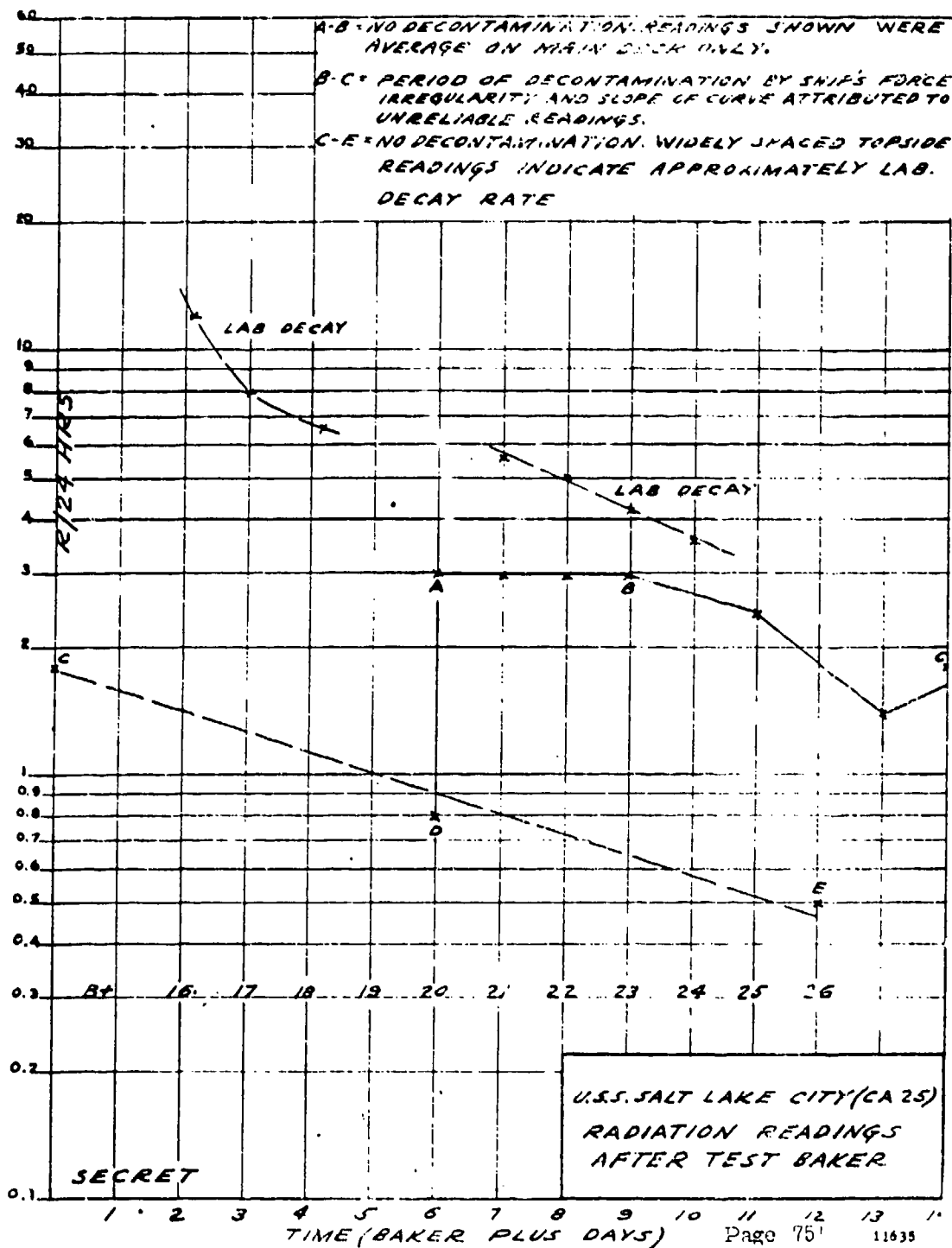
CA - 25

REPORT OF RADIOLOGICAL SURVEY - POST BAKER

Monitors: Lt. Cdr. SKOW (Sr. Off.)
Lt. Cdr. SMITH
Lt. Cdr. ELDRIDGE
Lt. HUFF
Lt. WELLS
Lt. (jg) ROUTT

Note: All readings are stated in Roentgens / 24 hours

SECRET



Main Deck and Superstructure:

	August					
	4	5	6	7	8	9
Water in aft. stbd. corner of wardroom	1.0	0.6	removed.....			0.3
Water in passage to Captain's Country	2.0	1.5	1.5	1.3	1.0	0.7
Landing to ComDeck stbd. side.	1.0	2.0	1.5	1.0	1.0	0.8
ComDeck aft - aver.	3.0	2.0	2.0	2.5	1.5	1.2
No. 3 5" sponson ave.	2.0	1.5	1.0	0.7	0.7	0.6
Water in #3 sponson	1.0	3.0	removed.....			
No. 1 5" spon-ave.	3.0	1.0	1.2	0.8	0.8	0.7
Water in #1 sponson	3.5	3.0	3.0	1.1	0.85	0.8
ComDeck - stbd. of Turr. #2 - deck average	1.5	1.5	1.2	0.9	0.9	0.7
Turret #2 stbd. bulkh'd	0.5	0.5	0.5	0.4	0.35	0.3
ComDeck - port aver.	1.0	1.5	1.0	0.7	0.8	0.5
ComDeck - port - aft of Turret #2	2.0	2.0	1.7	1.2	1.2	1.0
Radio I bulkh'd - port	1.0	1.0	1.0	0.57	0.4	0.4
No. 2 5" sponson	2.0	2.0	1.0	1.5	1.0	0.5

SECRET

· Main Deck and Superstructure:

	August					
	4	5	6	7	8	9
ComDeck, hatch to Capt's Country	1.0	1.0	1.0	0.7	0.8	0.5
No. 4 5" sponson	1.5	1.0	1.0	1.5	1.3	0.5
Water in #4 sponson	3.0	2.0	2.0	removed.....		
Drains in #2 sponson						
Stbd. aft	15	15	12	8	4	7
port aft	3	4	4	2	1.5	2
Drain head of ladder to pilot deck, port	15	15	10	5.5	5.5	5.0
Pilot Deck - port	12	3	3	3	3	4
Inside pilot house deck average	1.5	1.0	0.2	0.2	1.5	0.15
Pilot Deck, stbd. 20mm	15	15	8.0	1.0	1.0	0.7
Pilot Deck, stbd. aver.	20	4	3	2	2	2
Bridge, stbd. 40mm	6	2	2.0	0.9	0.9	0.7
Deck aft of Nav. Bolth	10	3	3	2.5	1.0	0.9
Open Bridge, fwd	15	3		2.5	1.5	0.7
Open Bridge, port	8	4	2	2.4	1.1	0.9
Bridge, port 40mm	3	2	2	2	0.58	0.6

SECRET

Main Deck and Superstructure:

	August					
	4	5	6	7	8	9
Radar Xmtr. deck port aft drain	20	20	20			14
Radar Xmtr. port-deck	4	4	4			3
Radar Xmtr. stbd-deck	6	6	6			6
Landing to ComDeck port side	2.0	1.5	1.5	1.0	1.2	0.9
Deck port of W.R.	1.0	1.5	1.0	0.9	0.6	0.4
Deck port of Turret #1	1.5	0.8	0.7	0.7	0.5	0.4
Focsl. port, wood	1.0	0.6	0.5	0.6	0.4	.35
Focsl. port, metal	0.4	0.4	0.3	0.5	0.3	.25
Eyes	0.3	0.3	0.2	0.4	0.2	.15
Focsl. stbd. metal	0.4	0.2	0.2	0.3	0.3	.15
Focsl. stbd. wood	0.8	0.5	0.4	0.5	0.4	.15
Deck fwd. of Turret #1	1.0	0.5	0.6	0.4	0.4	0.4
Stbd. of Turret #1 deck	1.2	0.8	0.7	0.6	0.5	0.4
Stbd. bulk'd Turret #1	1.8	0.4	0.4	0.4	0.4	0.3
Deck at Bos'n Locker	2.5	2.0	1.2	0.8	0.8	

SECRET

Main Deck and Superstructure:

	August					
	4	5	6	7	8	9
Deck stbd. of W.R.	1.0	0.8	0.7	0.7	0.4	0.4
Quarterdeck, average	2.0	1.5	1.4	1.2	1.0	0.8
Deck outside metal shop	2.0	2.0	2.0	1.2	1.0	1.0
Stbd. passage deck	1.5	1.2	1.2	1.0	1.0	1.0
Stbd. boat stowage	10	2.0	2.0	2.0	1.5	4.0
Deck outside CIC aft	3.5	2.0	2.0	3.5	1.5	1.5
Deck frames 110-120	2.0	1.5	1.2	1.1	0.8	0.7
stbd. 120-130	1.5	1.0	0.8	0.7	0.6	0.7
Metal deck 40mm	1.2	1.0	1.0	0.7	0.7	0.6
Wood fantail fr. 140	1.5	1.0	0.7	0.7	0.7	0.6
Charcoal on fantail	2.5	2.5	2.5	2.5	2.0	2.0
Deck frames 130	2.0	1.0	0.9	0.7	0.7	0.5
Port 120	1.2	1.0	1.0	0.7	0.7	0.5
110	1.2	1.0	1.0	1.1	1.0	
Chafing mattresses	more than 15		2.0.....		2.0	3.0
Gutter frame 110 P	000	1.5	1.5	1.8	1.5	
Gutter frame 105 P	80	2.0	2.0	2.0	2.0	

SECRET

Main Deck and Superstructure:

	August					
	4	5	6	7	8	9
Laundry vent cover	150	90	60	10	8.0	8.5
Port boat stowage	60	2.0	2.0	2.0	2.0	2.5
Deck about Messhall hatch	3.0	3.0	1.5	0.9	0.8	1.0
Port passage deck	3.0	1.0	1.0	1.4	2.0	1.2
Spud cleaner deck	10	15	15	32	10	8
drain outside	20	10	10	4	4	3
Port side well deck	2.0	1.0	1.0	1.2	1.0	.55
Well deck amidships	6	5	4	4	4	3.5
Deck at stbd. ladder	20	2	2	2	0.6	1.0
Port side aft of W.R.	2.0	1.5	1.5	1.5	0.8	.65
Ward room deck averg.	0.2	0.2	0.2	0.2	.15	.03
Door maindeck fr 109 S		10	10	8		
Galley		1.9	1.5	1.5	1.5	1.2
Wing stowage		20	20	48	4.0	2.5

SECRET

	August					
	7	8	9	10	11	12
Paint locker	.06	.06	clear.....			
Anchor windlass	.048	.048	clear.....			
Room 202	.048	.048	clear.....			
201	.036	.036	clear.....			
203	.036	.036	clear.....			
204	.072	.072	clear.....			
206	.06	.06	clear.....			
205	.036	.036	clear.....			
207	.048	.048	clear.....			
208	.060	.060	clear.....			
F10-30 passageway	.036	.036	clear.....			
F20 linen locker	.036	.036	clear.....			
F23 port blower	.036	.036	clear.....			
F23 port head	.084	.084	clear.....			
Room 210	.072	.072	clear.....			
209	.084	.084	clear.....			
Dark room	.060	.060	clear.....			
F29 heater room	.060	.060	clear.....			

SECRET

August

	7	8	9	10	11	12
Room 212	.048	.048	clear.....			
F37 head	.007	.007	clear.....			
Room 214	.072	.072	clear.....			
213	.017	.017	clear.....			
211	.024	.024	clear.....			
Troop Off. bunk rm.	.036	.036	clear.....			
Room 215	.009	.009	clear.....			
217	.009	.009	clear.....			
F40-48 crews space	.036	.060	forward area clear.....			
MAA shack (inside)	3.0	2.0	2.0			
MAA shack (outside)	4.0	4.0	2.2			
F48 center line	1.5	1.5	0.8			
F48 port	2.0	2.0	2.0			
Compt. at F48 port	0.2	0.2				
Blower at F48 port	0.45	0.45				
Blower at F48 stbd.	0.6	0.6				
F49 port crews head	0.45	0.50				
stbd crews head	0.5	0.5	0.4			
Fwd. edg fwd. uptake	1.3	1.3	0.8			

SECRET

	August						
	7	8	9	10	11	12	13
F52 stbd. hatch to B.R.	2.0	2.0	1.5				
1st lts. office	.060	.060	.040	clear.....			
Post office	.060	.060	.040	clear.....			
F62 stbd grating to BR	8.0	2.0	2.0				
Eng. office		1.0	.06				
Center fwd. uptake	1.5	10.0	3.0				
Fwd. uptake stbd.	8.0	8.0	7.0				
Water at oil shack	12	10	12				
F61 port blower room	3.0	4.0	3.0				
Fwd. uptake port	4.5	10	6.0				
Rec. Hall	.4	.4	.3				
Barber shop	.084		.036	clear.....			
F72 stbd door	2.0	1.0	0.8				
F72 port door	.14	.10	.60				
Electric shop	.10		.30				
F78 port head	.08		.03				
shower	.80		.03				

SECRET

		August						
		7	8	9	10	11	12	13
F78 uptake (port)		10	10	5				
(center)		20	20	10				
F78 port blower		1.5		4.0				
F86 machine shop		4	4	4				
stbd.		1.5	1.1	.5				
Mimeograph room		.24						
Mess hall port fwd.		.2	.2	.2				
mid		.4	.3	.4				
aft		14	.3					
Hatch to ice room		1.0	1.0	1.5				
Mess Hall stbd. fwd		.5	.5	.5				
mid		.6	.6	.6				
aft		1.5	1.5	1.5				
center		.5	.4	.4				
F80 machine shop		.2	.2					
Light shop		.1		.06				
Machine shop (inboard)		.8		.8				
Shipfitter's compt.		.08	.15					
F109-113 port		.072	.060	clear.....				
stbd		.096	.08	clear.....				
F113-119 port		.060	.060	clear.....				
stbd.		.060	.060	clear.....				

SECRET

August

	7	8	9	10	11	12	13
F119-128 port	.017	.01	clear.....				
stbd.	.06	.06	clear.....				
CPO mess port	.06	.06	clear.....				
stbd.	.06	.06	clear.....				
F132-140 port	.14	.07	.4				
stbd.	.19	.09	.4				
Aft head	.012	.05	.06				

SECRET

Page 35

D 32602

this symbol / stands for "less"

August

	6	7	8	9
15		0.1		
20		0.1		
27		.072		
29 Sick Bay	.06	.06	.04	
G.U. ward	.036		/ .1	/ .1
Dental		.036	.036	/ .1
P.R. steril		.048	.036	/ .1
O.A. outer bulk'd		.072		/ .1
Disp. window		.060		/ .1
Dis. outer bulk'd		.072		/ .1
GSK annex		.048	.024	/ .1
37 Passageway		.048		/ .1
GSK issue		.048	.036	/ .1
Small stores		.048		
48 A-310 stbd.	0.14	0.10		
A-310 center		0.52		
A-310 port	0.19	.072		

SECRET

Page 86

August

0 7 8 9

43 Diesel pump		.048	
Laundry	.14	.30	
1-4		.072	
4-10		.048	
Sail locker		.048	
15-18 Linen closet		.072	
18-23 Fresh water		.048	
A-607-A		.24	
A-506-A		.048	
Medicine locker		.036	
23-28 port		.036	
Sick Bay head		.036	.036
<u>Third Deck</u>			
28-30 Sick Bay Ward		.048	/ .1
Lab.		.036	/ .1
44-48 stbd. aft		.084	/ .1
port aft		.048	/ .1
Fire room #1	.072	.080	/ .1
Fire room #2 (near burner 1)	.072	0.60	/ .1

SECRET

Page 87

0 32602

Third Deck

August

6 7 8 9

Fwd. engine room				
4th deck	.072		.036 / .1	
3rd deck			.14 / .1	
Fire room #3	.072		.034 .08	
Fire room #4	.072		.034 .08	
Aft engine room				
3rd deck	.11		.08 .08	
4th deck	.11		.08 .08	
Ice room			.048	
Long shaft alley port			.060	
100 D-401 M			.036	
After gyro room			.036	
Long shaft alley stbd.			.024	
100-109 port and stbd.			.060	
109-119 port and stbd.			.048	
119-130 port and stbd.			.060	
130-138 port storage			.060	
stbd. storage			.060	
138-141 storage aft			.036	

SECRET

BB34
Serial 221

U.S.S. NEW YORK (BB34)

Care U. S. Post Office
San Francisco, Calif.

15 August 1946

From: The Commanding Officer.
To : The Director of Ships Material.

Subject: Report of Decontamination Progress, U.S.S. NEW YORK.

1. Following completion of washing down procedure by the tug on the afternoon of 6th August, first decontamination teams from the ship's company boarded on the 7th. These teams were relieved every two hours and returned to the ROCKBRIDGE. The day was spent mainly in jettisoning useless, highly radioactive material such as canvas, cargo nets, battered topside lockers, wood items and debris of all sorts. All life-rafts and floater nets were put overboard and secured to the side of the ship. Preliminary inspection of the ship, especially in the suspected flooded areas, were made by the Commanding Officer, together with the First Lieutenant and Carpenter. Engineering Department started the forward diesel generator for emergency light and power, and the forward diesel fire-pump, preparatory to furnishing water to wash down the main deck. Casualty power circuits were run to fuel oil service pump in #2 fireroom and to the submersible pumps being rigged aft, preparatory to pumping. C and R Department spent day making complete inspection of the fire-main and rigging the P-500 pump and submersible pumps so that pumping of flooded areas could be commenced first thing on the 8th. As water could not be obtained on deck until completion of inspection of the fire-main, decontamination could not start in earnest on the forecastle until sufficient working materials could be assembled. One group, in charge of a Chief Pay Clerk, spent the day scouting for boiler compound, lye, cornstarch, scrubbers, gloves, boots, and the like. Fresh water was hauled from the ROCKBRIDGE. By early afternoon water was obtained from the fire-main and the topside was washed down, particular attention being paid to the forecastle.

SECRET

15 August 1946

2. On the 8th of August, since necessary working materials were now assembled, decontamination on the forecastle began in earnest. Solutions of boiler compound and lye were used - lack of fresh water being a handicap, - and the forecastle was washed down several times. Sand was obtained and holystoning began. Cleaning up of the second deck was also started and numerous pools of water removed, debris cleaned up and loose gear that had been knocked about straightened up. The jettisoning of useless gear continued. The Engineering Department had started the forward diesel generator and diesel fire-pump for fire-main pressure. The diesel generator was connected to main distribution board through #12 fire-pump feed in order to supply power to the submersible pumps and to #3 fuel oil service pump. At 0900 fires were lighted off under #3 boiler and steam formed at 0950. At 1100 steam was cut in to the forward dynamo and #2 turbo generator warmed up. Pumping was commenced in the engine room, shaft alleys and storeroom bilges. At 1120 completed checking essential electrical circuits and at 1130 shifted electrical local from #1 diesel generator. At 1230 commenced pumping D-12 through secondary drain and flooded after diesel generator room through man-hole and opened gravity drain to port engine room bilges. Started pumping bilges. The C and R Department meanwhile was pumping aft with two submersible pumps in trunk D-38 and one pump in the C.P.O. mess room. Procedure was to work aft from D-38 to flooded steering gear room and steering room.

3. On August 9th forecastle was again washed down and holystoned with boiler compound, lye and sand. Fresh water still had to be hauled from ROCKBRIDGE in cans. Approximately 100 men were turned to on the second deck and considerable progress was made in cleaning up the second and third decks and officers' country. Others turned to cleaning up forward superstructure levels. General Field Day was held on the second and third decks, in the forward superstructure, and in the engineering spaces. Engineering Department washed out ice box, cleaned refrigeration plant and made ready for operation. Cleaned out boot shop. Started sick bay air conditioning unit. Ventilation system,

SECRET

15 August 1946

having been cleared by Radsafe, had previously been started. Drained after diesel fire pump and generator; tried to jack over by hand and found both frozen. Completed stripping forward group of fuel oil tanks. Replaced air casing on #1 boiler that was blown out on Test Baker. Cleaned up evaporator room and machinery; port set ready for operation. Washed down radioactive surfaces in the port engine room and blower room with boiler compound. Checked circuits to fresh water pumps and started same. Fresh water from the reserve feed bottoms cleared by Radsafe. Sent to Radsafe sample from fresh water gravity tank. C and R Department completed pumping D-112, D-38, D-37, D-35, and started pumping D-32. Both boat cranes were found to be operable and both planes were jettisoned.

4. On August 10th, forecastle was again holystoned with boiler compound, lye, and sand. Air castle and boat decks were washed down with boiler compound and lye, and the main deck aft washed down with salt water, preparatory to giving these decks the same treatment given to the forecastle. Engineering Department continued Field Day and Gunnery Department commenced decontamination of test torpedo and mine. C and R Department pumped out D-25, D-27, D-26-P, and D-26-S. Open seams found in D-12 and D-13, after trimming tanks. Wooden plugs were put in drain holes and other small holes to keep water out of D-25 and D-27 from the trimming tanks. Water also coming into D-27 from around steering gear shaft which was torn loose from the deck. As result of all pumping the trim aft was reduced from 5 feet to approximately 1 foot.

5. The following table shows results obtained in reducing the amount radioactivity on the forecastle due to holystoning with boiler compound, lye and sand.

SECRET

15 August 1946

Readings in Roentgens				
Frame No.	7th Aug.	8th Aug.	9th Aug.	10th Aug.
Bow	1.6	.7	.7	.6
10S	1.7	.6	.5	.45
10P	1.6	.5	.5	.5
20S	1.6	.62	.5	.5
20P	1.3	1.2	.5	.5
30S	1.5	1.3	.6	.6
30P	1.3	1.2	.5	.5
40S	2.0	1.1	.6	.5
40P	2.0	1.0	.7	.5

6. The following table shows amount of radioactivity on the main deck aft where decontamination consisted of cleaning up debris, jettisoning gear, sweeping and one (1) washing down with salt water.

Readings in Roentgens				
Frame No.	7th Aug.	8th Aug.	9th Aug.	10th Aug.
70S	1.6	1.6	1.2	1.3
70P	1.2	1.2	1.3	1.5
80S	2.0	3.0	.8	.9
80P	1.6	3.0	1.3	.9
90S	2.4	.5	.9	.6
90P	1.7	1.0	.9	1.0
100S	2.6	.7	.65	.6
100P	1.7	.8	.9	1.0
110S	1.5	1.3	1.0	.9
110P	1.2	1.5	2.0	1.3
120S	2.0	.8	.95	.8
120P	1.8	1.0	.9	.6
130S	1.8	1.5	1.0	.3
130P	1.6	*13.0	.8	.7
Stern	.99	1.5	2.0	--

*Paint chippings.

SECRET

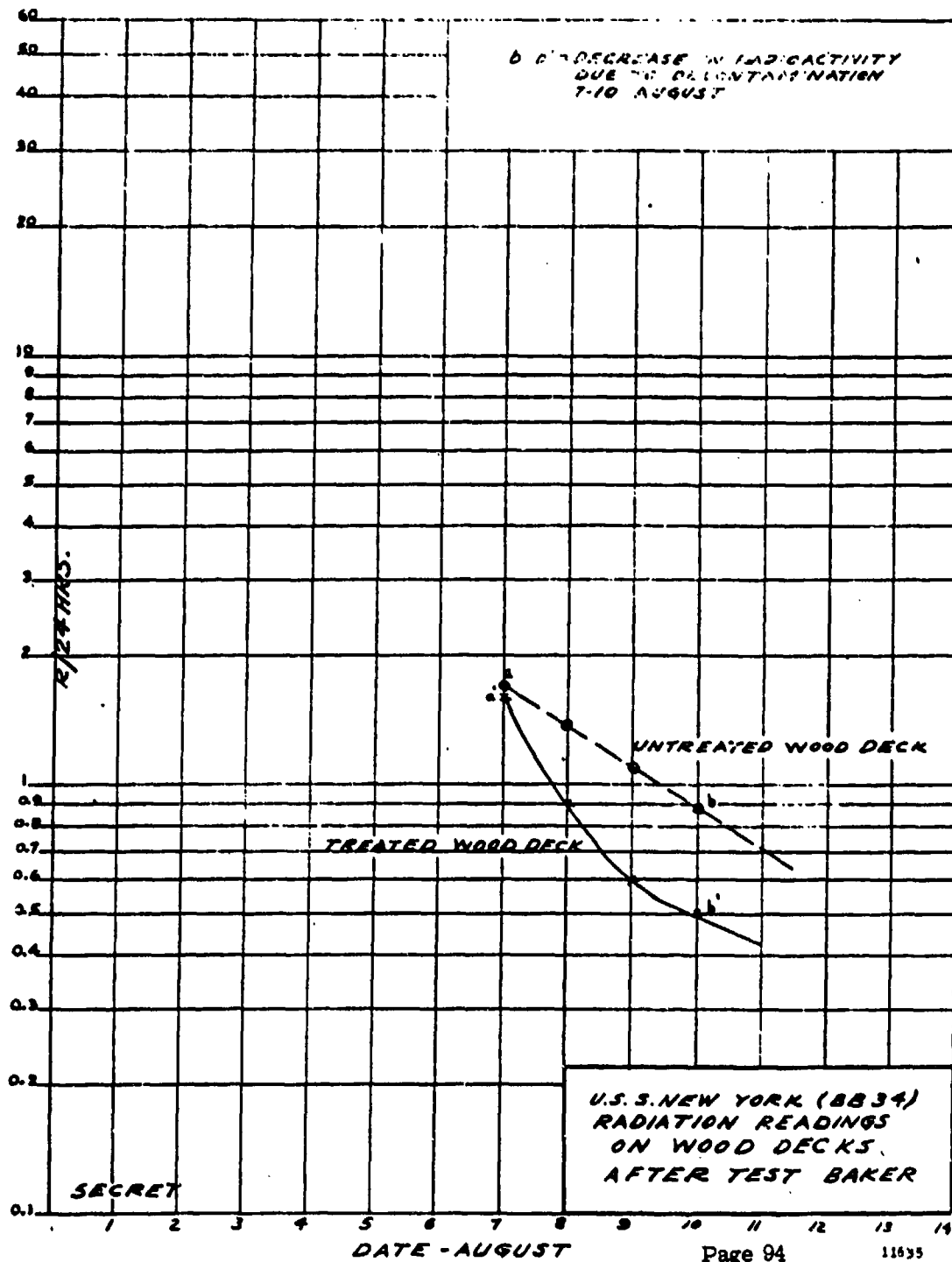
BB34 Serial 221

15 August 1946

As can be seen by these readings monitors were not consistent. Radio-activity on the main deck aft apparently reduced some with little or no decontamination process, although there was no radical decreases as were on the forecastle after only one application of holystoning with boiler compound, lye and sand.

R. J. CONNELL.

SECRET



CROSSROADS

U.S.S. WAINWRIGHT (DD419)

August 5, 1946

MEMO TO COMMANDER TASK GROUP ONE POINT TWO (JTF-1)

Subject: Test BAKER, Summary of reboarding operations, Aug.4-5.

Ship's personnel continued reboarding operations on WAINWRIGHT. This is an unofficial summary presented for whatever interest it may have.

August FOURTH Boarded at 0840 and evacuated at 1630.
2 groups relieved every 4 hours (topside).
1 group remained full time (engineering).
Lighted off #3 boiler and ship's service generator.
Continued scrub down with boiler compound-lye solution. Completed coverage all topside areas. Re-worked other areas previously treated as before. Scrubbed down sides with lye solution. Washed off with three hoses @ 120 lbs. 6-8 ft. distance using P-500 on LCVP. Jettisoned all canvas except cover #3 gun mount. Strung life rafts astern.

Complete closing up #2 boiler. 650# hydrostatic test pressure dropped 1 lb/min. Continued repairs pumps and electrical boxes after engineroom.

DSM ordnance and ECO electronics inspection groups aboard.

HAVEN monitors present.

August FIFTH Boarded at 0810 and evacuated at 1700.
2 groups @ 6 hours (topside).
1 group remained full time (engineers).
Lighted off #3 boiler and ship's service generator.
Continued scrub-wash down with lye solution all topside areas as before. Removed serving from lifelines-strung life floats astern.

Continued work engineering deficiencies as before.
HAVEN monitors present 0915-1530.

SECRET

GENERAL REMARKS:

A. Status engineering deficiencies at 1700L/5th.

1. Distilling condenser pump and motor on DIXIE for repair salt water damage-evaporators out pending return estimated 10 August.

2. Thrust collar #2 generator on DIXIE for sample mfg. new.

3. #2 main condensate and booster pump, scored bearing and cracked and frozen oil deflector ring-ship's force.

4. Magnetic electric controllers for condenser pump (1) above - ship's force attempting to dry out salt water damage after engineroom.

5. Boilers:

#1 - Out of commission with unlocated leak which occurs middle of tube nest above 150 lbs. pressure. Today's test leak did not appear until about 810#. Wedge cuts are the only way believed possible to locate this leak but ship's force has been working over four weeks attempting to locate by other means.

#2 - In commission for auxiliary (500 lbs.) steaming only. Believe 600# underway steaming would cause more tube failures.

#3 - OK

A. Radiological Aspects. Since reboarding the 1st ship has had 3 different monitors assigned. Recorded data for that monitor (and assistant) aboard on 3rd and 4th is attached for information and is only record available except that returned to HAVAN. The results of scrubbing and washing down (paint removal) are shown by the checks made on the 4th - are typical of results obtained, and for convenience are listed here:

SECRET

GENERAL REMARKS (Continued)

	Focsle Deck (Port)	4th - Before	4th - After
Frame	00	.3	.2
	10	.3	.2
	20	.4	.3
	30	.4	.25
	40	.4	.25
	50	.5	.35
	60	.5	.35
Break of deck	70	1.0	.5
	80	.3	.2
	90	.4	.25
	100	.5	.35
	110	.4	.35
	120	.4	.4
	130	.4	.25
	140	.4	.25
	150	.5	.3
	160	.4	.4
	170	.5	.4
	180	.45	.55
	190	1.0	.25
	200	1.0	.25
	210	1.4	1.10
	220	2.0	1.0
	230	1.4	.4

The main deck and focs'le deck today the 5th with washdown not fully completed indicated about a .15 port side and .1 stbd. The general average below decks today dropped to .1 or below. Full coverage has been made each morning on dry clean decks and time has allowed only a few checks after completion of days operations but indications are fairly conclusive that the decrease can be attributed to the paint removal. Readings the next day after about 16 hours are not decreased from the last previous days and in some cases seem to have increased. Because of the many factors involved there have been exceptions to the examples above which represent the over-all picture - - some have been better - - some not so good. Decontamination by the ship has been no more or less than paint removal by the use of caustic solution, elbow

SECRET

GENERAL REMARKS (Continued)

grease and solid steam high pressure wash. As the readings have decreased so has the "background" and such material as serving on lifelines now show up as "hot" are being removed.

Respectfully

L. W. SEDGWICK, Cdr., USNR Comdg.

cc: Dep DSM (W/O R readings)

U.S.S. WAINWRIGHT (DD419)

8 August 1946

MEMORANDUM TO COMMANDER TASK GROUP ONE POINT TWO.

Subject: Test Baker, Reboarding Operations, August 6-7-8.

Ship's personnel continued reboarding operations on WAINWRIGHT. This is an unofficial summary presented for whatever interest it may have.

August 6, 7, 8 Boarded 0800 and evacuated 1700 daily.

All hands remained full time.

Lighted off #3 boiler and ship's service generator.

Continued scrub-wash down with boiler compound-lye solution topsides and engineering upkeep.

HAVEN monitors present.

General Remarks.

(a) Status engineering deficiencies at 1700L/8th.

(1) Thrust collar #2 generator on DIKIE as sample for mfg new.

(2) Starboard engine jacking gear. Frozen gear ring. Ship's Force. Estimated completion 10th.

(3) Boilers. No. 1 and No. 3 OK. No. 2 suitable 500 lbs. auxiliary steaming.

(b) Radiological aspects. Main deck readings now average, .05-.06. At 1700L/8th est 99.9% topsides surface below .10 R/day. Monitor surveys now made with 263's and earphones. CRS boiler uptakes (port side) with all paint removed read .096 R/day. Bridge wings (port side) aluminum the same. No attempt to reduce upper surfaces of stack, masts--not deemed practicable unless made mandatory. Interior spaces below .10 - - today's surveys indicate contamination of passageways crews compartments, mess hall, etc., by

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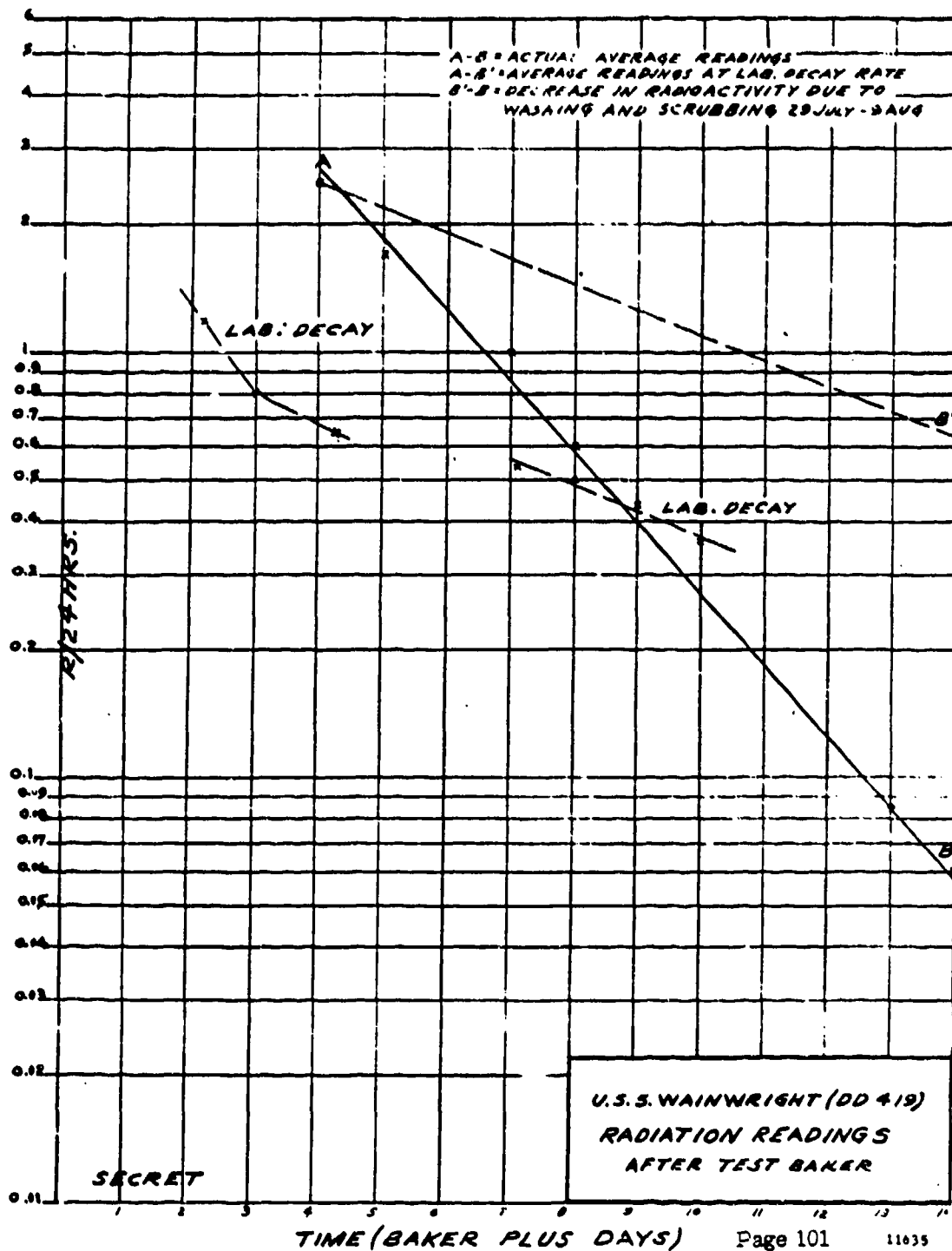
personnel from topside. Contamination is not excessive but is apparent. Some engineering valves above tolerance and have been marked for personnel to stay clear. Sonar room continues about .5 -- original readings below .10 in one icebox have increased to .3 plus -- investigation will be made tomorrow for contamination when cleaned several days ago. Hot material will "induce" (descriptive use only) steel for several feet around it. All monitors are unanimous in agreeing that underway in clear ocean water would materially help the radioactivity decrease.

In view of the present low level of radioactivity and the improvement in material condition of readiness in engineering this is the last summary report submitted and information concerning RFS, etc., will be furnished the group commander by regular channels.

Respectfully,

L. W. SEDGWICK
USS WAINWRIGHT
Commanding

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SOLID LINE - ACTUAL AVERAGE READINGS.

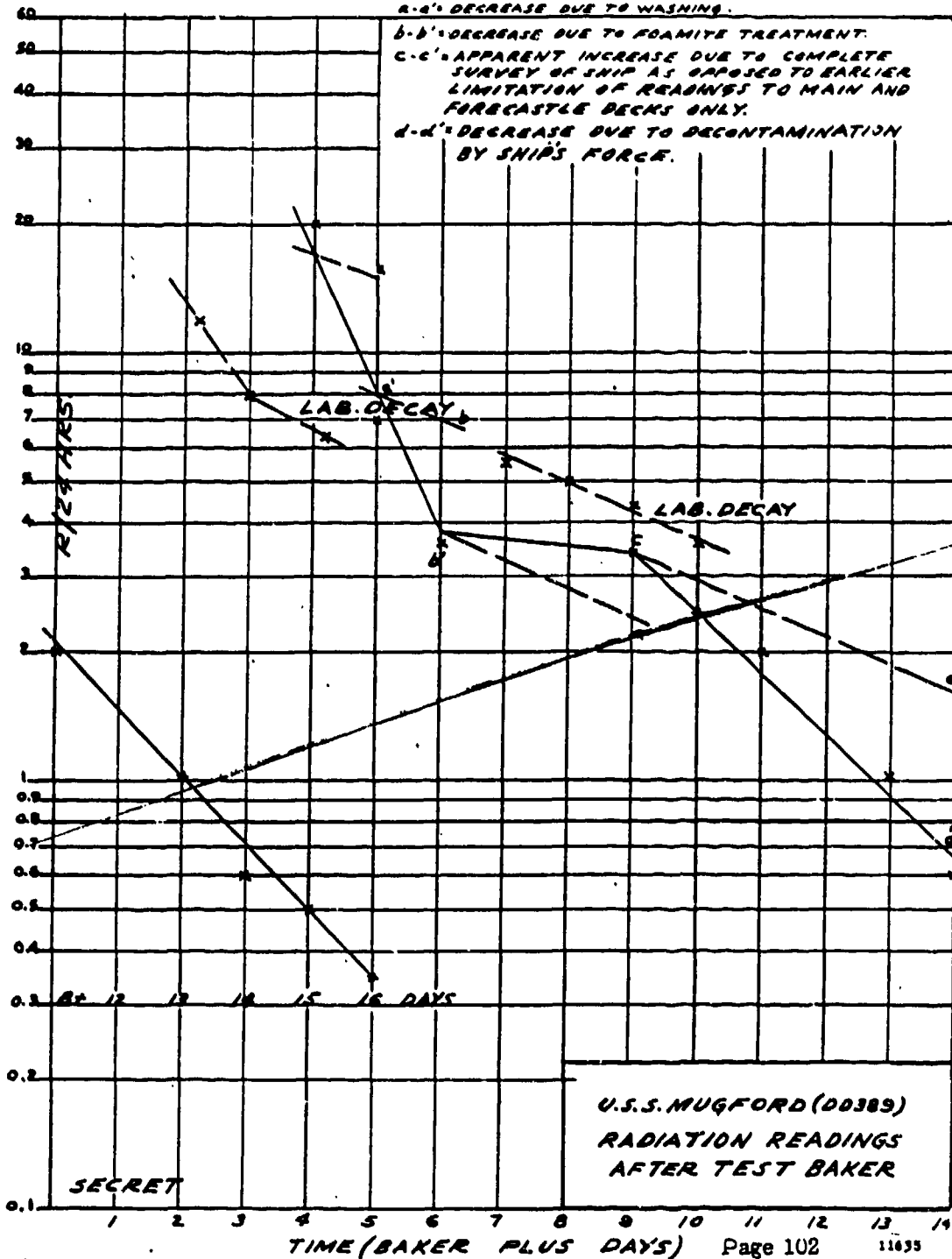
BROKEN LINE - AVERAGE READINGS AT LAB. DECAY RATE.

A-A' - DECREASE DUE TO WASHING.

B-B' - DECREASE DUE TO FOAMITE TREATMENT.

C-C' - APPARENT INCREASE DUE TO COMPLETE SURVEY OF SHIP AS OPPOSED TO EARLIER LIMITATION OF READINGS TO MAIN AND FORECASTLE DECKS ONLY.

D-D' - DECREASE DUE TO DECONTAMINATION BY SHIP'S FORCE.



0 32602

U.S.S. NIAGARA (APA-87)
c/o Fleet Post Office
San Francisco, California

20 August 1946

From: The Commanding Officer.
To : The Director of Ship Material.

Subject: Decontamination - Report on.

Reference: (a) CTG 1.2 Dispatch 190946Z of August 1946.

1. This ship was reboarded on 30 July 1946 (Baker plus 5). At that time the maximum Geiger reading obtained was 0.40 R/day. The compartments that were below the waterline had a higher Geiger count than others; at the time the radiological monitor stated that no man was permitted closer than five (5) feet to the ship's hull in these compartments. The afternoon of reboarding the NIAGARA got underway to shift her berth from the target array to less "hot" waters near the entrance of the lagoon.

2. For a day and a half after reboarding all decks and bulkheads in compartments above the waterline were washed down with soap and water. The sides of the ship were also scraped to a distance of approximately five (5) feet below the waterline to remove marine growth. No Geiger counter was available at this time so the effectiveness is not known.

3. On the afternoon of 1 August the NIAGARA got underway and put to sea to wash the ship's sides. A speed of ten (10) knots was maintained that afternoon and night. This reduced the Geiger count approximately 40%. The following morning speed was increased to fifteen (15) knots; however, this did not reduce the radioactivity any more.

4. Upon reentry into Bikini, hogging lines with scrapers attached were led around the ship and the bottom scraped in an attempt to remove some of the marine growth. After two days of scraping a

SECRET

monitor made an inspection finding the ship below 0.10 R/day throughout. The hottest spot was a portion of the ship's hull adjacent to the gangway; a reading of 0.095 R/day was obtained here. This reading was approximately 0.05 R/day higher than the rest of the ship. The safe distance from the ship's hull had been reduced from five (5) feet to one (1) foot. Therefore it was apparent that the scraping had done some good.

5. After the inspection by the radiological monitor two more days were spent in scraping the hull. During this time the entire bottom, sides, and waterline were scraped. This scraping was followed by another inspection on 5 August. At this time the monitors declared the ship radiologically safe in all parts and gave it RADSAFE clearance required to depart from Bikini.

6. Due to the position of the NIAGARA's anchorage, materials from decontaminated ships were washed against the ship. To prevent this material from clinging to the ship's sides the waterline was washed down each day for a week with fire hoses and the bottom was periodically scraped. At the end of a week another Geiger inspection showed a maximum of 0.082 R/day at frame 68; the rest of the ship was below 0.018 R/day.

7. With the exception of the procedures already mentioned, no decontamination was done on the ship. No paint was chipped or removed.

8. At the time of the blast the point of detonation was approximately on the ship's port quarter. The effect of this was noted from the Geiger readings even after the hull had been scraped several times. For instance the results of one inspection showed the following:

SECRET

Decontamination - Report on Cont'd.

<u>FRAME NO.</u>	<u>PORT</u>	<u>R/DAY</u>	<u>STBD</u>
14	0.042		0.036
28	0.018		0.054
42	0.024		0.015
57	0.017		0.012
68	0.080		0.048
82	0.052		0.024
93	0.053		0.018
107	0.042		0.072
110	0.079		0.072
122	0.096		0.048
135	0.036		0.012

W. H. STANDLEY, Jr.

cc:
CTG 1.2.

SECRET

014K2/A20

JOINT TASK FORCE ONE
DIRECTOR OF SHIP MATERIAL
U.S.S. WHARTON (AP7)

14 August 1946

MEMORANDUM

Subject: Comments on Radiation Measurements on Target Submarines.

Enclosure: (A) Tabulation of daily Geiger readings.
(B) Curves of Radioactivity Decay for DENTUDA, TUNA, SEARAVEN, PARCHE and SKATE.

1. Daily topside readings of surfaced submarines were taken at about three feet above deck with a Geiger - Mueller counter at five selected spots. These readings were recorded in Roertgens per twenty-four hours and are tabulated in enclosure (A). Monitors taking readings and the instruments with which they were taken varied from day to day.

2. Trends indicated by curves plotted from the above-mentioned readings and pertinent information on the ships concerned is as follows:

DENTUDA - Had been submerged during Test Baker and was surfaced on Baker plus two. Ship is about a year and half old, paint is very thin and there is very little rust. Decontamination measures consisted primarily of topside scrubbing by ship's force using lye and boiler compound. The curve shows a rapid continuous rate of decay with a half life of about 2.5 days.

TUNA - Had been submerged during Test Baker and was surfaced on Baker plus two. Ship is old and has considerable paint and rust. Decontamination methods consisted primarily of topside scrubbing

SECRET

by ship's force and also a lye and boiler compound bath followed by a wash applied by an ATF on Baker plus 5 and 6. The curve shows an initial decay rate similar to that of the DENTUDA with a half life of about 2.5 days which lengthens to about 3.5 days as the radiation approaches 0.1 R/24 hours.

SEARAVEN - Had been submerged during Test Baker and was surfaced on Baker plus four. Ship is old and has considerable paint and rust. Decontamination measures consisted of daily scrubbing by ship's force after Baker plus five together with several lye and boiler compound baths applied by an ATF after Baker plus 12. The curve shows an initial decay rate similar to that of the DENTUDA with a half life of about 2.5 days with a later change at Baker plus twelve to half life of about 5 days. Note that this is similar to the half life indicated for the PARCHE and SKATE, both of which had been on the surface for Test Baker.

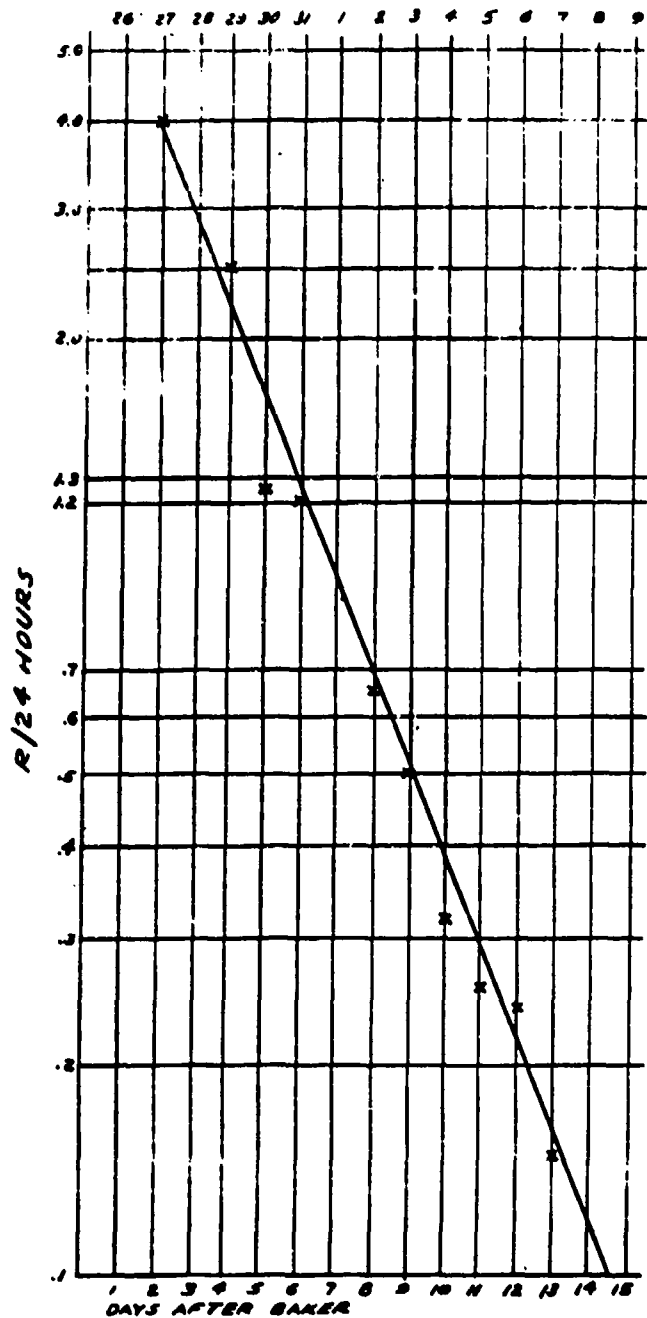
PARCHE - Had been surfaced during Test. Ship has an average accumulation of paint and rust. Decontamination measures consisted of limited daily scrubbing by ship's force after Baker plus six with lye and boiler compound bath and also wash treatments applied by an ATF at intervals on and after Baker plus twelve. The curve shows an initial decay rate with a half life of about 4.2 days followed by a definite reduction in measured radiation at Baker plus twelve and a resumption of a steady decay rate thereafter with a half life of 4.5 days. This is the only positive indication in any of the submarine curves of the probable effectiveness of decontamination measures in reducing the overall average radiation from this type vessel.

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SKATE - Had been surfaced during Test Baker. Most of the superstructure and decking had been blasted from the vessel in Test Able leaving the bitumastic covered hull fully exposed. The curve shows an unchanged decay rate with a half life of about 5.2 days. Decontamination methods and measures are indicated on the chart.

3. No effect has been made to co-relate indicated radiation on Baker Day with distance from the center of blast. Knowing decay rates of sodium salts or other substances with which the ships may be contaminated, the date, particularly for the TUNA and SEARAVEN, may be useful in indicating type and degree of contamination. Shifting of berths of the TUNA and DENTUDA on Baker plus three and the SKATE on Baker plus six from the target area to uncontaminated moorings does not appear to be significant.

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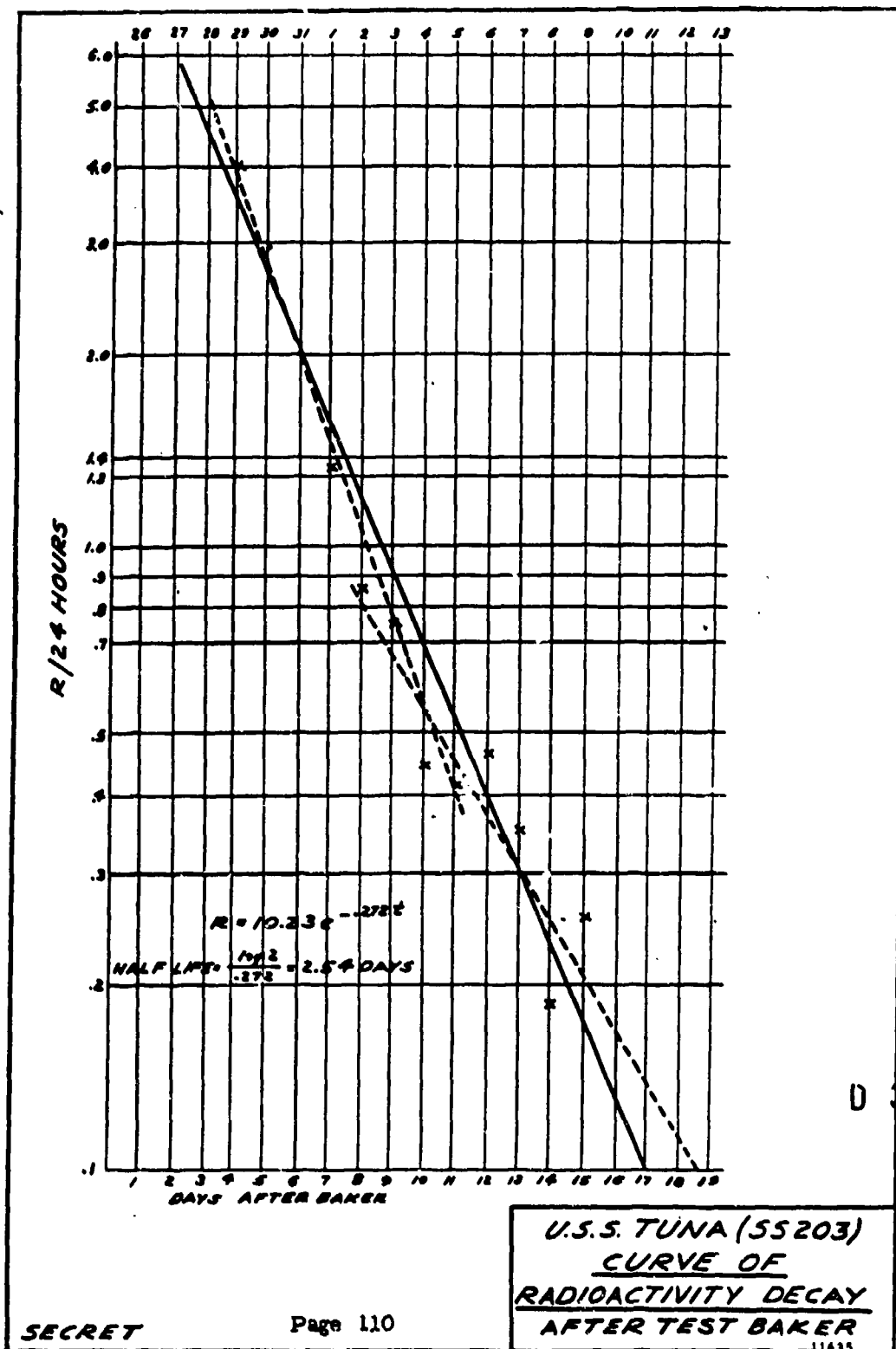
$$R = 7.05e^{-.283t}$$

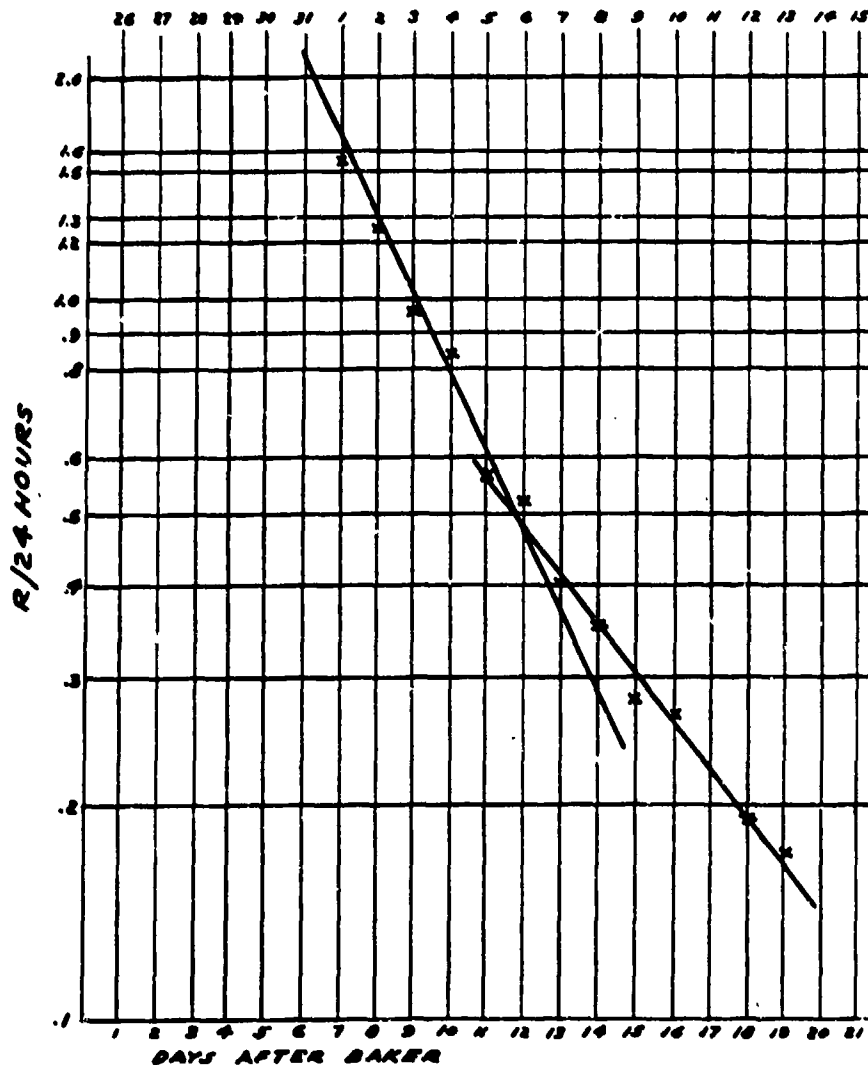
$$\text{HALF LIFE} = \frac{\log 2}{.283} = 2.45 \text{ DAYS}$$

U.S.S. DENTUDA (SS 335)
CURVE OF
RADIOACTIVITY DECAY
AFTER TEST BAKER

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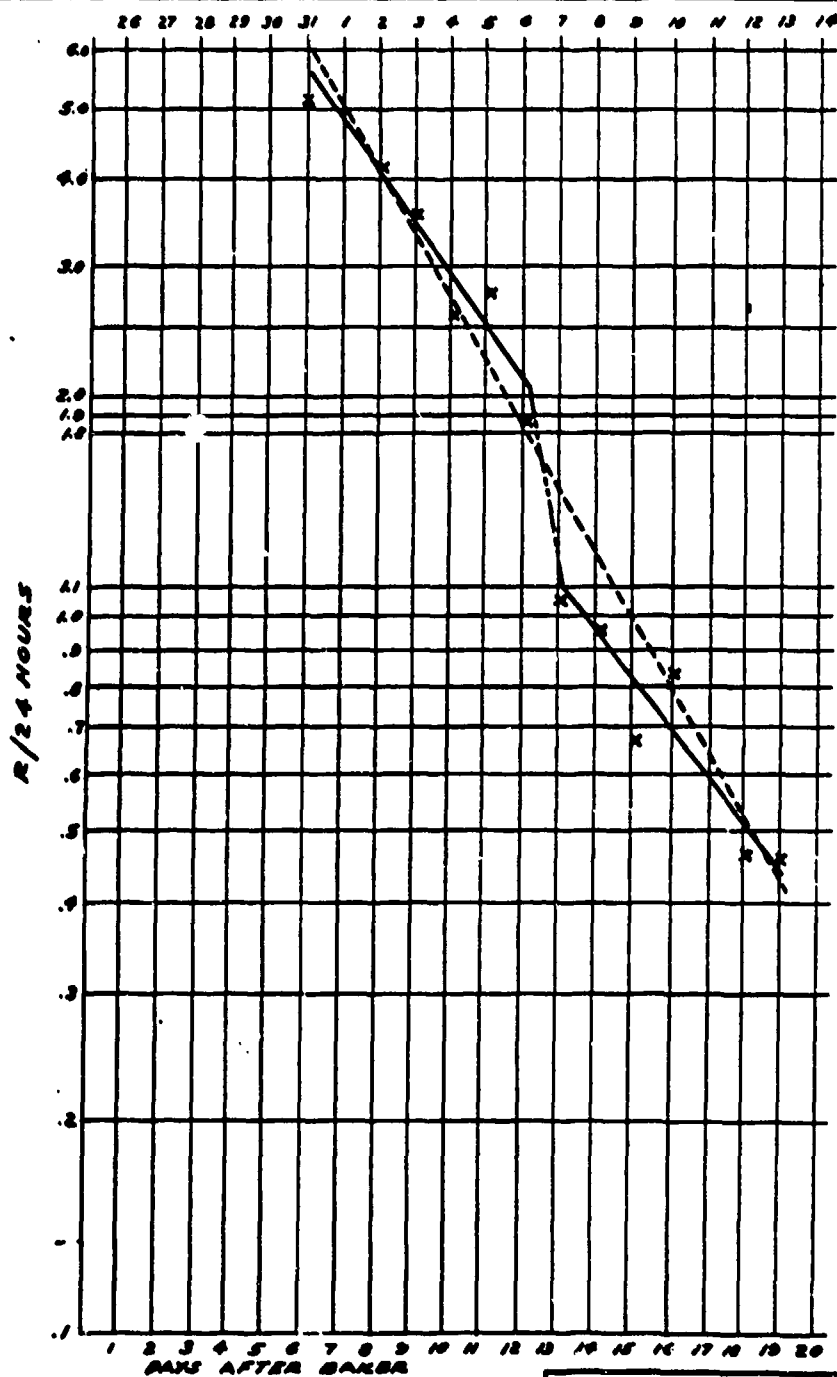




U.S.S. SEARAVEN (SS 196)
CURVE OF
RADIOACTIVITY DECAY
AFTER TEST BAKER

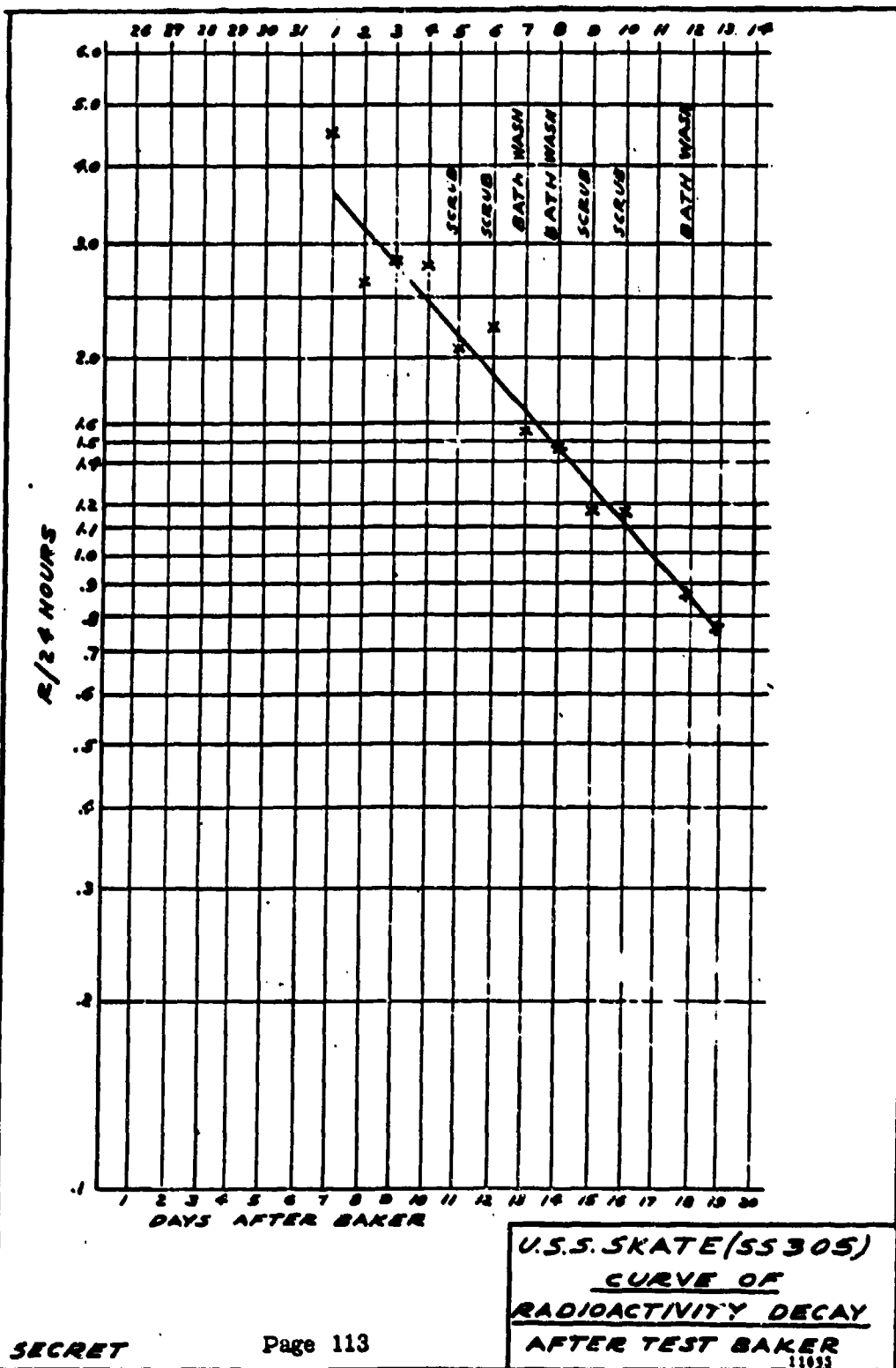
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11A38



U.S.S. PARCHE (SS384)
CURVE OF
RADIOACTIVITY DECAY
AFTER TEST BAKER
 11631

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SUBMARINE RADIATION

U.S.S. DENTUDA (SS335)

<u>Date</u>	<u>Bow</u>	<u>Fwd. CT</u>	<u>Aft C.T.</u>	<u>Aft</u>	<u>Stern</u>	<u>Average</u>	<u>Remarks</u>
25							
26							
27						4.0	
28							
29						2.5	
30	1.2	1.25	1.6	1.0	1.2	1.25	
31	1.2	1.1	1.5	.95	1.2	1.2	
1							
2	.7	.7	.85	.5	.6	.67	
3	.45	.6	.5	.42	.5	.5	
4						.31	
5						.26	
6	.2	.3	.3	.2	.2	.24	
7	.12	.16	.15	.15	.14	.15	
8	.05	.06	.06	.05	.05	.054	
9	.048	.06	.072	.06	.048	.057	
10	.036	.038	.05	.038	.036	.04	

SECRET

SUBMARINE RADIATION

U.S.S. DENTUDA (SS335)

<u>Date</u>	<u>Bow</u>	<u>Fwd. CT</u>	<u>Aft C.T.</u>	<u>Aft</u>	<u>Stern</u>	<u>Average</u>	<u>Remarks</u>
11							
12	.04	.04	.096	.04	.038	.051	
13	.03	.03	.07	.02	.05		
14							
15							
16							
17							

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SUBMARINE RADIATION

U.S.S. TUNA (SS203)

<u>Date</u>	<u>Bow</u>	<u>Fwd CT</u>	<u>Aft C.T.</u>	<u>Aft</u>	<u>Stern</u>	<u>Average</u>	<u>Remarks</u>
25							
26							
27						8.0	
28							
29						4.0	
30							
31							
1	.8	1.9	2.0	1.0	1.0	1.34	
2	.8	.85	.95	.88	.82	.86	
3	.6	.7	.85	.9	.7	.76	
4						.44	
5						.41	
6	.4	.47	.48	.52	.45	.46	
7	.28	.34	.41	.43	.33	.36	
8	.15	.18	.20	.23	.20	.19	
9	.21	.28	.3	.3	.2	.26	
10	.05	.06	.072	.072	.06	.063	

SECRET

SUBMARINE RADIATION

U.S.S. TUNA (SS203)

<u>Date</u>	<u>Bow</u>	<u>Fwd Ct</u>	<u>Aft C.T.</u>	<u>Aft</u>	<u>Stern</u>	<u>Average</u>	<u>Remarks</u>
-------------	------------	---------------	-----------------	------------	--------------	----------------	----------------

11

12	.08	.12	.12	.11	.075	.101	
----	-----	-----	-----	-----	------	------	--

13	.08	.09	.10	.12	.11	.10	
----	-----	-----	-----	-----	-----	-----	--

14

15

16

17

SECRET

SUBMARINE RADIATION

U.S.S. SEARAVEN (SS196)

<u>Date</u>	<u>Bow</u>	<u>Fwd. C.T.</u>	<u>Aft C.T.</u>	<u>Aft</u>	<u>Stern</u>	<u>Average</u>	<u>Remarks</u>
25							
26							
27							
28							
29							
30							
31	2.5		5.0	4.0		3.83	
1						1.54	
2	1.0	1.25	1.5	1.0	1.5	1.25	
3	.67	.85	1.15	.87	1.2	.95	
4						.82	
5						.56	
6	.4	.6	.6	.45	.5	.51	
7	.3	.46	.50	.35	.38	.40	
8	.25	.37	.35	.31	.42	.34	
9	.2	.25	.35	.37	.25	.28	
10	.26	.22	.32	.35	.22	.27	

SECRET

SUBMARINE RADIATION

U.S.S. SEARAVEN (SS196)

<u>Date</u>	<u>Bow</u>	<u>Fwd. C.T.</u>	<u>Aft C.T.</u>	<u>Aft</u>	<u>Stern</u>	<u>Average</u>	<u>Remarks</u>
11							
12	.15	.2	.23	.2	.2	.196	
13	.14	.20	.20	.18	.16	.176	
14							
15							
16							
17							

SECRET

Page 119

D 32602

SUBMARINE RADIATION

U.S.S. PARCHE (SS384)

<u>Date</u>	<u>Bow</u>	<u>Fwd. C.T.</u>	<u>Aft C.T.</u>	<u>Aft</u>	<u>Stern</u>	<u>Average</u>	<u>Remarks</u>
25							
26							
27							
28							
29							
30							
31	2.5	4.0	8.0	8.0	4.0	5.1	
1							
2	4.0	5.5	7.5	2.0	1.5	4.1	
3	4.2	5.3	5.6	1.6	.92	3.52	
4						2.6	
5						2.77	
6	1.5	3.0	3.5	.8	.5	1.86	
7	.56	1.45	2.5	.42	.38	1.06	
8	.54	1.50	2.10	.35	.37	.97	
9	.45	1.0	1.4	.3	.2	.67	
10	.45	1.3	1.8	.35	.18	.82	

SECRET

SUBMARINE RADIATION

U.S.S. PARCHE (SS384)

<u>Date</u>	<u>Bow</u>	<u>Fwd. C.T.</u>	<u>Aft C.T.</u>	<u>Aft</u>	<u>Stern</u>	<u>Average</u>	<u>Remarks</u>
11							
12	.35	.7	.94	.2	.15	.47	
13	.32	.68	.89	.22	.18	.46	
14							
15							
16							
17							

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D 32602

SUBMARINE RADIATION

U.S.S. SKATE (SS305)

<u>Date</u>	<u>Bow</u>	<u>Fwd. C.T.</u>	<u>Aft. C.T.</u>	<u>Aft</u>	<u>Stern</u>	<u>Average</u>	<u>Remarks</u>
25							
26							
27							
28							
29							
30							
31							
1	3.0	5.5	7.0	4.0	3.0	4.5	
2	2.6	2.6	3.3	2.5	1.8	2.56	
3	3.0	3.0	3.8	2.2	2.0	2.8	
4				-		2.7	
5						2.04	
6	2.0	2.5	2.5	3.0	.85	2.37	
7	1.5	1.65	2.4	1.7	.46	1.54	
8	1.5	1.65	2.3	1.55	.35	1.47	
9	.6	1.5	2.3	1.0	.4	1.16	
10	.4	1.3	2.0	1.5	.64	1.17	

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SUBMARINE RADIATION

U.S.S. SKATE (SS305)

<u>Date</u>	<u>Bow</u>	<u>Fwd. C.T.</u>	<u>Aft. C.T.</u>	<u>Aft</u>	<u>Stern</u>	<u>Average</u>	<u>Remarks</u>
11							
12	.35	1.25	1.5	.85	.42	.87	
13	.46	1.1	1.35	.65	.31	.77	
14							
15							
16							
17							

SECRET

Page 123

D. 62002

APPENDIX II

CJTF-1 Serial 079

of

9 September 1946

Note: This letter was superseded partially by Joint BuShips - BuMed confidential speedletter serial 1381 of 24 September 1946. (See Appendix IV). Both were superseded entirely by Joint BuShips-BuMed confidential letter All/Crossroads/C-s(99) - (c) of 22 November 1946, a copy of which is contained in Appendix IV.

SECRET

Page 124

D 32602

JTF-1/J-3/-
FILE: L9-7
Serial: 079

JOINT TASK FORCE ONE

9 September 1946

CONFIDENTIAL

From: Commander Joint Task Force ONE.
To: Commanding Officers of Ships Listed in enclosure A.
Subject: Ships, Radiological Safety of.
Reference: (a) CJTF-1 Confidential letter, serial 075 dated 19 August 1946.
(b) CJTF-1 Confidential dispatch 282110Z of August 1946.
Enclosure: (A) List of ships present at Bikini for sufficient period following Test Baker as to be radiologically suspect.
(B) Technical instructions for radiological Monitors (Conf.)
(C) Radiological Safety instructions to be followed by all ships pending complete monitoring and clearance.
(D) Copy of CJTF-1 Confidential letter, serial 075 of 19 August 1946.

1. Reference (a), which is Enclosure (D) hereto, sets forth certain steps which would have to be taken before complete and final radiological clearance could be given any ship which was at BIKINI Atoll after Test BAKER. It was considered at that time that the steps prescribed in that letter would be sufficient, but further information and results of laboratory analyses have indicated that additional safeguards are required. After discussion with CJTF-1 Radiological Safety Adviser, Com-ServPac in his 240111 August promulgated to type commanders and district commandants certain steps which would have to be taken, and recom-

SECRET

CONFIDENTIAL

Subject: _____ Ships, Radiological Safety of _____

mended reassembling at San Francisco the ships which had been subjected to possible contamination. This dispatch proposed a criterion of 10 days presence at Bikini after July 25 as constituting a possibility of contamination, but CJTF-1 in his 282110 stated that he considered all addressees of Reference (a) (and of this letter) as suspect, despite the fact that some of them had been present less than 10 days. Also in his 282110 CJTF-1 concurred in the assembling of the affected ships at San Francisco for resurvey and radiological clearance, with the provision of facilities also at Pearl Harbor, and the flying of monitors and equipment to Guam to provide resurvey and clearance there for ships which had proceeded to the westward from Bikini. Later, when it appeared that San Francisco might be unduly crowded by the assembling there of such a large number of ships, CJTF-1 arranged for the expansion of the monitoring organization to include the other principal west coast ports (the headquarters, however, remaining at San Francisco under COM12).

2. CNO 302200 of August directed that when ships arrived at the west coast, Pearl Harbor of Guam, carrying boats which had been exposed to radiological contamination, such boats were to be monitored under the direction of the District Medical Officers, and boats which were found to be unsafe were to be sunk at sea in deep water.

3. The purpose of this letter is to advise individual commanding officers of the foregoing sequence of communications (most of which were addressed only to type commanders and district commandants), and also to summarize safety precautions and give information as to the monitoring and clearance organization and procedure.

4. Enclosure (C) constitutes a summary of safety precautions which should be followed until complete and final radiological clearance has been obtained. It should be emphasized that the "clearance" which all ships obtained before leaving Bikini was only a permission to sail, and did not constitute a clearance within the meaning of this letter.

SECRET

CONFIDENTIAL

Subject: _____ Ships, Radiological Safety of _____

5. Enclosure (B), the technical instructions for monitors, is included for information.

6. It will be noted that the list of addressees of this letter (which is also a list of ships which must be considered radiologically suspect until cleared) does not include ships which were a part of the target array, even though later re-manned and now operating. Such ships will be handled and cleared by Commander Naval Task Groups.

7. The radiological Organization is as follows:

(a). CJTF-1, Washington, D. C., through his radiological Safety Adviser, will define the policy to be followed by the monitoring organization.

(b). Captain W. E. WALSH, MC, USN., JTF-1 Medical Officer operating from the office of the District Medical Officer, Twelfth Naval District, will coordinate the monitoring work necessary for final clearance at Pearl Harbor, T.H., and on the West Coast. He will obtain and assign to the District Medical Officers of the 11th, 12th, 13th, 14th Naval Districts, and Guam necessary monitors and instruments. He will promulgate and distribute Technical Instructions to the Radiological monitors.

(c). An advisory board of senior civilian scientists is available to Captain WALSH, as are necessary laboratory facilities.

(d). The Radiological Safety Officers or monitors will be assigned to the District Medical Officers for administration and will make the actual surveys.

8. As each of the suspect ships reaches the port to which it has been ordered for radiological monitoring and clearance, it will arrange with the District Medical Officer for monitoring. The monitoring organization, under the District Medical Officer, will make a thorough survey of the ship, and provide advice and technical assistance in the elimina-

SECRET

CONFIDENTIAL

Subject: _____ Ships Radiological Safety of _____

tion of such contamination as is found. When the ship is found to be safe for unrestricted use (either as a result of initial monitoring or after decontamination work) the monitoring organization will so advise the District Commandant, who will then address a dispatch to the ship giving radiological clearance, and including as addressees CNO, CJTF -1, CinCPac, BuMed, and the ship's type commander. In some few cases it may be found impossible to eliminate certain of the contamination; in such cases a conditional clearance will be given setting forth what further decontamination will be required and what precautions must be taken in the interim. Such conditional clearances, however, are highly undesirable in that they limit operation and will eventually cause immobilization through lack of maintenance; accordingly they should be given only when the elimination of the contamination is manifestly impracticable, and only after Captain WALSH (Para 7 (b) above) has been consulted to insure that there are no further facilities which might avail.

9. In addition to the above dispatch report, the monitoring organization will forward by mail a complete report of the conditions found on each ship. to BuMed with copies to CNO, the ship's type commander, CJTF -1, CinCPac, the ship, and Captain W. E. WALSH (MC) USN., care District Medical Officer, 12th Naval District.

10. Once this program is underway the Chief of Naval Operations will issue a weekly summary showing the current radiological status of each ship listed in Enclosure (A), this to be sent to all information addressees of this letter.

11. District Medical Officers are requested to prepare adequate copies of Enclosure (B) for use by the Radiological Safety Monitors under their cognizance.

12. It is essential that it be understood that there is a serious potential hazard involved here, which requires close attention to the safeguards laid down in Enclosure (C). It involves important factors whose

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CONFIDENTIAL

Subject: Ships, Radiological Safety of

presence in appreciable quantity has been definitely determined only after the departure of most ships from Bikini. There is no reason to believe that any personnel have been subjected to any serious hazard as yet but the safety precautions issued as Enclosure (C) herewith must be rigidly observed until a Radiological survey has been made and clearance given

F. J. LOWRY
Rear Admiral, U. S. N.

cc:

CNO
BuMed
CinCPac
ComServPac
ComAirPac
ComDesPac
ComBatCruPac
ComPhibsPac
ComSubsPac
CominPac
Com 11
Com 12
Com 13
Com 14
ComWesseeFron
ComHawseeFron
ComNavShipyards Mare Island
ComNavShipyards Bremerton
ComNavShipyards Terminal Island
ComNavShipyards Pearl Harbor
CNB Pearl Harbor.

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CONFIDENTIAL

Subject: Ship's Radiologic Society of.

cc: (cont)

Com Marianas

CNB Guam

ComNavPhil

BuShips

ComGenManhattan District

CTG 1.2

Radsafe JTF-1.

CTG 1.3

ComDesRon 7

ComDesDiv 72

ComServDiv 11

DSM

Captain W. E. Walsh, MC., USN.,

c/o District Medical Officer,

12th Naval District.

Comdr. E. P. Harris, MC., USN.,

USS HAVEN (AF H-112),

c/o FPO San Francisco.

SECRET

LIST OF SHIPS PRESENT AT BIKINI FOR
SUFFICIENT PERIOD FOLLOWING TEST
BAKER IS TO BE RADIOLOGICALLY SUSPECT

MOUNT McKINLEY AGC-7
AVERY ISLAND (AG-76
HAVEN APH-112
WHARTON AP-7
KENNETH WHITING AV-14
FALL RIVER CA131
ARTEMIS AKA21
APPLING APA58
GYPSY ARSD-1
MENDER ARSD-2
PALMYRA ARST-3
PRESERVER AR-8
DELIVER ARS-23
CLAMP ARS-33.
CURRENT ARS-22
CONSERVER ARS-39
RECLAIMER ARS-42
WIDGEON ASR-1
COUCAL ASR-8
ETLAH AN-79
SUNCCOK AN-80
ONEOIA (AN-85
SHACKAMAXON AN-88
ATA - 180
ATA - 185
ATA - 192
ACHOMAWI ATF-148
CHICKASAW ATF-83
ATR - 40
ATR - 87
LCT - 1184
LCT - 1420
ROLETTE AKA-99
LST - 817
LST - 881

GEO CLYMER APA27
HENRICO APA45
BOTTINEAU APA-235
BEXAR APA-237
ROCKWALL APA230
ROCKINGHAM APA-229
ROCKBRIDGE APA-228
ORCA AVP-49
BARTON DL-722
SUMNER DD-692
FLUSSER DD-368
LAFFEY DD-724
MOALE DD-693
HUNINGTON DD-781
IOWPY DD-770
INGRAHAM DD-694
DIXIE AD-14
COASTERS HARBOR AG-74
HESPERIA AKS-13
POLLUX AKS-4
ENOREE AO-69
TOMBIGBEE AOG (W)-11
AJAX AR-6
PHAON ARB-3
TELAMON ARB-8
CEBU ARG-6
ARD - 29
CREON APRL-11
SPHINX ARL - 24
FULTON AS-11
ATA - 187
ATA - 124
CHOWANOC ATF-100
MINSEE ATF-107
WENATCHEE ATF-118

SECRET

Enclosure (A)

WILDCAT AW-2
LST - 388
LST - 861
YF - 890
YF - 733
YO - 132
YO - 199
YOG - 63
YOG - 70
YW - 92
QUARTZ IX-150
PRESQUE ISLE APD-44
GUNSTON HALL LSD - 5
SAN MARCOS SLD-25
LCI - 977
LCI - 1062
PGM - 24
PGM - 23
PGM - 25
PGM - 29
PGM - 31
PGM - 32
LCT - 1361
LCT - 1461
LCT - 1359
BENEVOLENCE AH-13
BOWDITCH AGS-4
JOHN BLISH AGS-10
JAMES M. GILLIS AGS-13
YP - 636
YMS - 354
YMS - 358
YMS - 413
DUTTON AGS - 8
BRAMBLE WAGL
SYLVANIA AKS-44
YMS - 433

SIOUX ATF-75
APL - 27
SAIDOR CVE-117
N. K. PERRY DD-883
BURLESON APA-67
ST CROIX APA231
LCI - 1091
WALKE DD-723
OTTAWA AKA-101
BEGOR APD-127
CHICKASKIA AO-54
BAYFIELD APA83
CUMBERLAND SOUND AV-17
NIAGARA APA-87
LCI - 1067
O'BRIEN DD725

Enclosure (A)

SECRET

TECHNICAL INSTRUCTION FOR MONITORS

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TECHNICAL OPERATION SHIP CLEANANCE

Mission To detect and avoid radiological hazards connected with ships.

Situation.

1. Ships steaming or anchored in water which is contaminated with products of an atomic bomb explosion, may collect some of these radioactive products (a) in pipes and drains carrying salt water, (b) in the scale which forms on the inner walls and shells of evaporators and condensers and (c) on the external surfaces of the hull, particularly near and below the water line where marine growth and encrustation are common.

2. The longer the ship operates within such contaminated water and the greater the use of the salt water systems, the greater the likelihood of such contamination and the more extensive the contamination which may take place within the ship.

3. JTF-1 ships operating within the lagoon at Bikini subsequent to 25 July 1946 may have and those with accumulated total of ten days subsequent thereto probably have become contaminated as in paragraph 1 above.

Organization-

1. Trained radiological personnel surveyed each ship prior to its departure from Bikini.

2. The Commanding Officer of each ship was given a temporary radiological clearance report including written instructions relative to precautions to be taken when cleaning or repairs might open up radioactive deposits.

3. In ports of arrival from Bikini area, liaison between radiological monitors and District of Port Medical Officers is essential.

SECRET

4. District Medical Officers will be provided with an approved list of trained monitors within that district.

5. It is essential to inform command concerned with ship movements, and operations officers, as well as cognizant yard manager and commanders.

Preparation.

1. Equipment needed: (a) A portable Geiger counter or other sensitive detector or alpha, beta and gamma rays. (b) In borderline cases samples of scale, rust, marine growth, etc. should be collected by the monitor and sent to the laboratory for analysis.

2. The particular places on deck to look for retained radioactive material are:

Depressions, low places, pumps, drains, scuppers, anywhere that water may collect and evaporate, rusty places, canvas, cordage especially unpainted or checked.

3. The radioactivity will decay with time and the intensity of radioactivity at a given place may be reduced by removal of the radioactive material. Both processes are important in safety operations.

4. The radiological status of an area of an object and the subsequent intensities thereof should be measured with a Geiger Counter or Ionization chamber.

5. For gamma rays the maximum tolerable limit of occupancy is set at 0.1 R of gamma ray per day (24 hrs.).

6. For beta rays, if the intensity in several times the gamma measurement, the tolerance limit for beta rays localized exposure to hands and feet is set at 0.5 R per day and for total body radiation with betas 0.1 R 24 hrs.

7. Among the products of nuclear fission, which may be found after an atomic bomb burst are both beta and gamma emitters. These are always accompanied by alpha emitters. These particles, once in the body,

SECRET

act like radium, are many times more toxic, and are known to be most toxic chemical yet known. The tolerance level can not be given at this time. It is accumulative as far as a retention in body is concerned. The lethal dosage for an adult man is microscopic in amount. The measurement of alpha emitters in the field is difficult and, where there is any doubt, samples should be sent to the laboratory.

8. Materials contaminated with alpha emitters may present a serious inhalation hazard. Therefore all materials showing beta and gamma activity should be considered as presenting as well an alpha particle hazard.

9. One month after the Baker bomb test the original gamma ray hazard had decayed to a level where it failed to act as a red flag dramatically warning people to keep away from contaminated surfaces. Furthermore, the absence of this warning has tended to establish in the uninformed individuals an unjustified sense of security. Although the gamma and beta intensities are reduced greatly or entirely absent, the presence of alpha emitters continues so that henceforward, alpha ray emitters will have to be dealt with as such.

10. Until a dependable field instrument is developed and made available for detection and measurement of alpha particles, their presence must be presumed to exist and the intensity of the hazard calculated indirectly for beta and gamma activity. The appropriate beta-alpha count ratio and relation to time elapsed after bomb burst provides strong presumptive evidence of their presence.

11. All surfaces once contaminated with beta emitters should be considered as presenting a continuing alpha emitter hazard until it can be proven otherwise by appropriate radiochemistry analysis. Repairs on such surfaces, including wire brushing, sand blasting and welding on such surfaces should be undertaken only when proper safety precautions can be followed.

SECRET

GENERAL CLEARANCE AND SAFETY ASPECTS

1. Hull. (a). The outer surfaces of the hull particularly close to the water line and just below may collect radioactive materials. The green seaweed that grows at the water line picks up and concentrates such materials very actively. Corals and barnacles do likewise but he is actively so. Presumably no ship will arrive at a home port with gamma ray intensities above tolerance from hull contamination. (b) In spite of this reduction in gamma activity, alpha emitters persist in only slightly reduced amounts and the drying, scraping and sand blasting of such hull in drydock can present a serious inhalation hazard and a lesser ingestion hazard. The minute radioactive particles may be inhaled or ingested.

(c) Suitable protection can be provided against these hazards in the conduct of such work if safety precautions directed toward this end are strictly followed (See otherwise.)

(d) The scraping of such hulls by scraping tackle or by hand from stagings slung above the water line does not carry this hazard if wet technique is employed. Much of the algae growth can be scraped off with safety employing long handle scrapers over the side.

2. Small Boats. (a) These may present activity on their hulls, in salt water cooling lines and particularly in rusty spots and propellers. (b) When taken aboard ship these boats will present an additional alpha particle hazard within the ship, and should not be cleaned or scraped. Painting over the rust is only a stop gap procedure. The contamination is covered over only temporarily. It will emerge later perhaps in subtle and undesirable form.

3. Salt Water Lines. (including the fire lines and some steering tubes) (a) These will all pick up radioactivity from such contaminated water (Presumably in the iron rust for which the particles have particular affinity or in the corrosion lining them).

(b) They seldom present gamma ray hazard although at the height of radioactivity after Test Baker, a few such situations did compel evacuation of outboard tiers of bunks in some ships.

(c) Repairs involving gas cutting or arc welding could produce dangerous fumes through vaporizing particles contaminated with alpha emitters or by producing radioactive fumes or dusts.

SECRET

4. Heads and Drains. (a) These usually show activity due to continued flushing with contaminated salt water.
(b) The beta and gamma from the toilet bowls or urinals will probably not be hazardous, for the period of occupancy of these is brief.
(c) The overhead pipes and boxes may be quite active with gamma or beta rays, yet not dangerous because no one is near them for long.
(d) Repairs thereon may be hazardous from alpha emitters.

5. Rope Fenders, and cordage, swabs and gloves, may be contaminated and should be disposed of by sinking in deep water.

6. The Anchor and Chain, if they have been in contact with a highly radioactive bottom, may possess much radioactivity.

7. Loss of Radioactivity. The radioactive materials deposited on hulls and in salt water lines rarely, if ever, washes off completely, even when operating in clean sea water. After losing some of the more loosely bound and superficial materials the decrease in the contamination will come about only by means of natural radioactive decay, or by complete removal. Even they in some instances the plain metal may retain some alpha activity.

EVAPORATOR CLEARANCE

1. General. (a) One of the most bothersome problems has been the collecting of radioactivity in the scale in the ship's evaporators. This has resulted from the deposition of various salts and other materials due to the concentration and precipitation of whatever is in the sea water.
(b) The proper use of starch and boiler water treatment compound in evaporators, as well as other commonly used methods, effectively prevented collection of radioactive scale.

2. Distillate free from radioactivity. (a) A most fortunate feature is the failure of the radioactive materials to go over into the distillate.
(b) If fresh water lines were to be found radioactive, one would suspect a false cross connection with salt water line.

3. Radiological Hazards. (a) Gamma rays, coming out through the shell, have run occasionally to several times tolerance level, but only seldom dangerous at the place there the attendant stands (or sits) habitually. The radioactive material washes out of some ships after steam-

SECRET

ing into the clean ocean water for a while and thereafter decays more and more slowly. The condenser and other salt-water piping may present a hazard similar in essential respects.

(b) Material presenting beta rays and alpha emitters is encountered in the scale when evaporator is opened.

REMOVAL OF SCALE

1. Removal of scale through the hand-hole should not be done to reduce the gamma ray hazard through the shell, for it will prove ineffective. If necessary to remove scale by an open method in order to keep the evaporator running, then a wet process should be employed and certain precautions should be observed.

(a) Canvas or similar sheeting spread to collect scale as it is scraped out, letting none fall into bilges or elsewhere. Scale together with canvas in which it is collected to be thrown over the side into the open sea (never into a harbor with poor exchange of water with open sea). A shallow metal pan may be used for this purpose.

(b) Scale kept wet at all times.

(c) Workman wear rubber gloves.

(d) Avoid direct contact with the scale.

(e) Any loose scale scraped up and then the area mopped up, and the scale thrown over the side together with the mop, bucket, dust pan or canvas used for this.

(f) Contaminated deck areas hosed down after replacing hand hole cover.

(g) All workmen involved have thorough showers and don fresh clothing.

(h) A monitor present at the first such cleaning to instruct personnel in hazards and safe practices.

2. Manual removal of scale from the tube nest, or by "hotshocking" is a grave health hazard due to the possibility of involving very toxic materials.

(b) If the evaporator is operated correctly it should not be necessary.

(c) If, nevertheless, it is unavoidable, then special monitoring must be provided throughout the operation and certain precautions observed.

(a) Conducted on downwind side of weather decks.

(b) Restricted area screened off by wet canvas.

(c) Scale, evaporator tubes, canvas, decks, etc. kept wet at all times.

SECRET

(d) Operators wear positive pressure air masks, or Navy rescue oxygen breathing apparatus afterward. Also gloves, and clothing which should be discarded. (Ordinary filter type gas masks will not protect personnel).

(e) All loose scale must be scraped up and the area mopped up, mop canvas and scale to be thrown over the side in deep or rapidly mixing water.

(f) Areas of the decks around evaporator, areas along path over which the tube nest was carried, and the space where the cleaning was carried out should be thoroughly hosed down.

(g) All workmen must have showers and fresh clothing.

3. Removal of Tube Nest. gets rid of some of the radiological hazard, but does not remove it all. It is hazardous and requires the presence of a monitor.

4. Acid Cleaning. The use of inhibited acid, is fairly effective and radiologically reasonable safe.

5. Boil out. With high temperature water and with boiler compound, try to remove scale. Advantage is radiological safety, since evaporator is not opened

6. Vapor Compression Evaporators. These are usually of corrosion-resistant alloy and can be cleaned by the circulation of acid solution. The evaporator is not opened and the method avoids radiological hazards. Under these circumstances, open methods of scale removal should not be used.

7. Heat Exchangers. These may be so contaminated as to require the avoidance of or actual postponement of cleaning. Most desirable is:

- (a) Replacement with a new unit, throwing the old one over the side. If not available, consider,
- (b) Cleaning by inhibited acid process.
- (c) Cleaning mechanically under the precautions listed for hand cleaning of steam. evaporators tube nests.

SECRET

**RADIOLOGICAL SAFETY INSTRUCTIONS TO BE
FOLLOWED BY ALL SHIPS PENDING COMPLETE
MONITORING AND CLEARANCE.**

1. The following information should be promulgated to all ships and Navy Yards.

(a) Welding or cutting operations on salt water lines, evaporators, condensers or on the hull at or below the water line in closed spaces may be done under the following conditions.

- (1) The extent of metal cut in a closed space should be limited to ten (10) linear feet during any 24-hour period.**
- (2) The operation should be protected with a positive pressure mask or Navy rescue breathing apparatus.**
- (3) Unprotected personnel should be excluded from the compartment.**
- (4) Ventilating system should be shut down during welding or cutting operations.**
- (5) A suction apparatus should be used in a closed space with the intake end as close as possible to the work. The exhaust end should be so cared for that personnel will not be nearer than 15 feet upwind nor closer than 100 feet downwind.**
- (6) Gloves should be worn by the welder and discarded by sinking upon completion of the work. Thorough scrubbing of the hands with soap and water.**
- (7) Cutting or welding in the open should not be done near an air intake.**
- (8) Same precautions to be observed as in closed spaces except for suction apparatus.**

SECRET

- (9) It is recommended that whenever possible cutting of pipe lines be done with a hack saw and blades to be discarded upon completion of the job.
 - (10) After a cutting or welding operation of the maximum degree (10 linear feet), the space should be monitored, washed down and painted as early as practicable.
- (b) Marine growth on hulls should only be removed under the following conditions:
- (1) A radiological monitor should be present.
 - (2) The hull should only be scraped while wet.
 - (3) Long handled scrapers should be used.
 - (4) At present all work should be performed in floating dry-docks situated where there is rapid exchange of water.
 - (5) All material removed should be thoroughly flushed from drydock and dock subsequently monitored.
 - (6) Hulls should not be sand blasted.
 - (7) Clothing of all employees should be monitored and discarded if above set tolerances.
- (c) Small Boats:
- (1) The propellers, exhaust pipes, all rusted hull surfaces below water level, and cooling systems of many small boats have become contaminated. It is recommended that all small boats which exceed the tolerance dose be placed in an isolated portion of a Navy Yard or that they be destroyed by sinking, not burning.
 - (2) Other measures which may protect personnel are of a temporary measure. No work on the motors, cooling system, propellers or rudder should be done. Sanding

SECRET

wire brushing or sand blasting is specifically prohibited as the dust hazard is very serious on contaminated boats.

- (d) **Evaporators.** The concentration of radioactive material in the scale of evaporators presents a serious problem. At the present time, it is recommended that evaporators be opened for manual scaling or repairs only in the presence of a monitor. The following precautions should be prescribed when manual scaling is necessary to keep an evaporator operating.
- (1) A shallow metal pan, canvas or similar sheeting spread to collect scale as it is scraped out, letting none fall into bilges or elsewhere--scale in its canvas all together disposed of over the side in deep water where rapid water exchange occurs.
 - (2) Scale kept wet at all times.
 - (3) Workmen wear rubber gloves and avoid direct contact with the scale.
 - (4) All loose scale mopped up and thrown over the side, together with mop, bucket or canvas used to collect scale.
 - (5) Deck areas hosed down after replacing hand-hole cover.
 - (6) All workmen involved have thorough showers and fresh clothing.
- (e) **For manual removal of scale from tube nest the following precautions are recommended.**
- (1) A monitor should be present.
 - (2) Scaling operation conducted on the downwind side of the weather deck.
 - (3) Restricted area screened off by wet canvas.
 - (4) Scale, tubes, canvas and decks to be kept wet at all times.

- (5) All operators wear positive pressure masks or Navy rescue breathing apparatus, gloves, and clothing which should be discarded.
 - (6) All loose scale must be mopped up; mop, canvas and scale disposed of by sinking at sea.
 - (7) Deck areas around evaporator, along the path over which the tube nest was carried and the cleaning space thoroughly hosed down.
 - (8) All workmen must have showers and fresh clothing.
 - (f) Deck gear. Cane and manila fenders that are contaminated should be disposed of by sinking at sea as their porosity renders decontamination very difficult. Personnel handling these articles should scrub their hands thoroughly with soap and water.
6. The advice of the monitors should be followed in arranging for the discarding of clothing, equipment and all contaminated materials.

U.S.S. MT. McKINLEY (AGC-7), Flagship
c/o FPO, San Francisco, Calif.

P2-4
Serial: 075

19 August 1946.

CONFIDENTIAL

From: Commander Joint Task Force ONE.
To: Commanding Officers of Ships Listed in
Enclosure (A).

Subject: Monitoring of ships to check radiological
contamination.

Enclosure: (A) Ships present Bikini area from 25 July
to 10 August.

1. The ships listed in Enclosure (A) were present at Bikini following Atomic Bomb Test Baker and sustained radiological contamination in varying degrees.
2. Each ship which was sufficiently contaminated as to give rise to any possibility of personnel casualty, was given (or will be given) prior to its departure from Bikini area, instructions as to steps to be taken to prevent over-exposure of personnel. However, in most cases such instructions took the form of limitations on the lengths of time which personnel could spend in certain compartments or in the vicinity of certain pieces of equipment. It was generally impracticable to make any predictions as to the periods during which such contamination would continue. It is to be hoped that the extensive steaming in the open sea, which must follow departure from Bikini area, plus the natural decay of radioactive matter, will soon eliminate any possibility of hazard to personnel from radioactivity.
3. Before ships can be considered completely clear however, further monitoring will be necessary, particularly to insure the safety of personnel engaged in scraping ships' bottoms or doing work on evaporators (it has been found that foregoing are the two principal collecting points for

radioactive matter).

4. Arrangements are being made for radiological monitors to be available for call to naval shipyards and principal ports on the west coast and at Pearl Harbor. Commanding Officers of ships addressed should make request for such monitors before carrying out any work involving opening up evaporators or other contaminated machinery, or before entering dry dock. The district medical officer of each naval district should be contacted to obtain such monitors. If difficulty is experienced in obtaining monitors, inform Commander Joint Task Force ONE, Chief of Naval Operations, and the Chief of the Bureau of Medicine and Surgery by dispatch. Copies of report of such monitoring should be furnished the ship, Chief of Naval Operations, Chief of the Bureau of Medicine and Surgery, and the ship's type commander.

/s/ J. A. SNACKENBERG,
Chief of Staff.